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ABSTRACT

This color-coded competency-based teacher guide contains two units: (1) safety; and (2) equipment, applications, and techniques. Each unit includes the following: objective sheet--unit and specific objectives; suggested activities/instructional plan--preparation, delivery and application, evaluation, teaching suggestions, resources used in developing this unit, suggested supplemental resources, suggested activities, and instructions for evaluating student performance; answers to written test; written test; unit evaluation form; teacher supplement; transparency masters; information sheets; and job sheets. The following general information is provided: use of this publication; competency profile; instructional/task analysis; related academic and workplace skills list; and tools, equipment, and materials lists. (NLA)

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Shielded Metal Arc Welding

Second Edition

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- Safety
- SMAW applications
- Basic joints, all positions
- Air carbon arc gouging
- Hardfacing

Teacher Edition

MAVCC

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Shielded Metal Arc Welding

Second Edition

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Shielded Metal Arc Welding, Second Edition

Teacher Edition

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Foreword

Shielded metal arc welding continues to be the essential skill for welding. While gas metal arc and other welding processes have replaced SMAW in many applications, learning how to "stick" weld is still the best jumping off point because it introduces students to welding machines, metals, welding electrodes, and the concept of "shielding" that retains its vital role in other welding processes.

Shielded Metal Arc Welding (second edition) retains a substantial amount of the original publication. Technically, the second edition emphasizes changes in definitions to reflect definitions and standards set by the American Welding Society (AWS). Graphics depict correct "views" and symbols as students weld on different joints in different positions. All symbols agree with AWS standards.

These instructional materials are designed not only for student use, but to assist teachers in improving instruction. Sequencing of components in the introductory materials and units of instruction are the biggest change to be found in *Shielded Metal Arc Welding (second edition)*. The written tests and transparency masters are no longer included in the student edition. Introductory materials include a competency profile, instructional/task analysis, tools and equipment list, a list of reference materials, and a summary of academic and workplace skills being reinforced in the publication.

Special attention should be given to the teacher suggestions in each unit of instruction. These suggestions present ways to increase reinforcement of academic and workplace basic skills. By reinforcing basic skills, the teacher will assist students in improving their employability skills.

As you use these instructional materials, we hope you will find they contribute to the quality of your program. We feel you will appreciate the technical changes in the second edition and the streamlined format in which it is presented. Every effort has been made to make these materials readable and by all means useable. You as a teacher, will need to develop instructional strategies for localizing, individualizing, and supplementing the text, and motivating the students who whork with these instructional materials. As always, MAVCC appreciates hearing from users of our publications. Please write or call MAVCC and share what you liked about *Shielded Metal Arc Welding (second edition)* and/or what you think needs to be changed.

Larry Nelson, Chairman
Board of Directors
Mid-America Vocational
Curriculum Consortium

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Acknowledgements

Appreciation is extended to those individuals who contributed their time and talent to the development of *Shielded Metal Arc Welding, Second Edition.*

The contents of this publication were planned and reviewed by the following members of the Mid-America Vocational Curriculum Consortium *Shielded Metal Arc Welding, Second Edition* committee:

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We also thank the committee which met to plan and approve the original *Shielded Metal Arc Welding.* The popularity of the text documents their successful effort. Special thanks to the many manufacturers whose procedures and illustrations have been used as models to authenticate and enhance our test. Another thank you goes to the American Welding Society for their contributions in helping us maintain technical accuracy.

A final thank you goes to the personnel of the Oklahoma Department of Vocational-Technical Education for excellent wordprocessing, art work, and printing.

Use of Introductory Materials

Introductory materials are included in the teacher guide only and contain useful information to assist administrators and teachers in planning for instruction.

In addition to the general information such as the table of contents, foreword, and acknowledgements page, information is included on the following:

1. **Use of this publication**—Explains the components of a unit of instruction and how they should be used as part of the teaching/ learning process.
2. **Competency profile**—Provides a record of student performance for each task included in a unit of instruction. This becomes a part of the student's permanent records and should be utilized when directing the student toward employment opportunities.
3. **Instructional/task analysis**—Provides a quick review of contents of the publication; identifies cognitive (knowledge) skills and psychomotor (performance) skills addressed in each unit of instruction.
4. **Related academic and workplace skills list**—Classifies unit tasks (assignment sheets and job sheets) according to related academic and workplace skills being reinforced. Skill areas reflected by skill groups, sub skills, and descriptions have been identified using *Workplace Basics: The Skills Employers Want*, developed by the American Society for Training and Development (ASTD) and the U.S. Department of Labor and adapted by MAVCC.
5. **Tools, equipment, and materials list**—Provides a comprehensive list of those items needed to successfully complete the assignment sheets and/or job sheets; assists administrator/teacher in determining program costs.
6. **Reference list**—Provides a comprehensive list of resources used in the development of this publication.

As you use these materials, it is hoped that they will provide useful information to meet a variety of needs.

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Use of This Publication

Instructional units

Shielded Metal Arc Welding, Second Edition, contains 2 units of instruction. Each instructional unit in a teacher guide includes some or all of the following basic components of a unit of instruction: objective sheet, suggested activities for the teacher, answers to assignment sheets, answers to written test, written test, unit evaluation form, teacher supplements, transparency masters, information sheet, assignment sheets, student supplements, and job sheets.

All of the unit components focus on measurable and observable learning outcomes. Teachers are encouraged to supplement, personalize, localize, and motivate with these materials in order to develop a complete teaching/learning process.

Units of instruction are designed for use in more than one lesson or class period of instruction. Careful study of each unit of instruction by the teacher will help to determine the following:

- Amount of materials that can be covered in each class period.
- Skills that must be demonstrated.
- Amount of class time needed for demonstrations.
- Amount of time needed for student practice.
- Supplementary materials, including print and nonprint media and equipment and supplies, that must be ordered.
- Resource people who must be contacted.

Objective sheet (Color code: White)

Each unit of instruction is based on performance objectives which state the goals for successful completion of the course. These performance objectives are stated in two forms: unit objectives which state the expected performance of each student after completion of the unit of instruction, and specific objectives which state what the student must do to reach the unit objective.

The objectives should be provided for students and stressed throughout the teaching/learning process. This will help answer any questions concerning performance requirements for each instructional unit. The objectives can also help determine teaching strategies and instructional methods. Teachers should prepare for each unit by deciding how each objective can best be taught.

Teachers should feel free to modify, delete, or add objectives in order to meet the needs of the students and community. When objectives are added, the teacher should remember to supply the needed information, assignment and/or job sheets, and criterion test items.

Suggested activities (Color code: Pink)

This component is included only in the teacher guide. The suggested activities assist teachers during the preparation stage of the teaching/learning process by providing an instructional plan, teaching suggestions, and a list of supplemental resources. Ways to integrate academic and workplace skills have been included in the teacher suggestions, and skill areas have been noted in bold. (A table of academic and workplace skills with accompanying definitions has been provided on page xv.) The teacher should read the suggested activities before teaching the units and decide how each objective can best be taught. Time should also be allowed to obtain supplemental materials, prepare audiovisual materials, and contact outside resources. Duties of the teacher will vary according to the particular unit.

References used in the development of each unit are listed in the suggested-activities section, along with suggested supplemental resources that may be used to teach the unit. These materials can be used by the teacher to supplement her or his knowledge of the subject area or to help students with particular interests or objectives in the area covered.

Instructions for evaluating student performance on the job sheets are also included in the suggested-activities section. Teachers should select and discuss with students the rating scale that will be used.

Assignment and written test answers (Color code: Pink)

Assignment-sheet answers and written-test answers are designed to assist the teacher in evaluation of student performances.

Written test (Color code: Yellow)

This component provides criterion-referenced evaluation of every cognitive objective listed in the unit of instruction. The test appears in the teacher guide only, but duplication is permitted for student use. If objectives have been added, deleted, or modified, appropriate changes should be made on the written test. It is recommended that the tests be divided into shorter tests covering three or four objectives at a time and given soon after those objectives have been covered. A selection of test items from the units covered may be used for final tests at the end of each term if desired.

Unit evaluation form (Color code: White)

This sheet provides teachers with a record of each students performance on a unit of instruction. It includes space for assignment sheet ratings, job sheet ratings, written test scores, and teacher comments. The unit evaluation form is included in the teacher guide only, but may be duplicated.

Teacher supplements (Color code: White)

This component is included only in the teacher guide. Teacher supplements are optional materials for the teacher to use. They have three purposes: to provide the teacher with higher level materials to stretch the advanced student, with remedial information or practice to assist the less-advanced student, and with state-of-the-art information in which the teacher may not have background or with information that is not readily available in other books. Some teacher supplements may be duplicated for student use and are marked accordingly.

Transparency masters (Color code: White)

Transparencies are included in the teacher guide only and are used to direct the students' attention to the topic of discussion. They may provide illustrations, charts, schematics, or additional information needed to clarify and reinforce objectives included in the unit of instruction.

Information sheet (Color code: Green)

The information sheet provides the content essential for meeting the cognitive (knowledge) objectives of the unit. Teachers will find that the information sheet serves as an excellent guide for presenting background knowledge necessary to develop the skills specified in the unit objective. Students should read the information sheet before the information is discussed in class. Space is provided in margins for students and teachers to add notes that supplement, localize, personalize, or provide information for the teaching of each objective.

Student supplements (Color code: White)

Student supplements are included in the student manual. The information presented in a student supplement may consist of tables, charts, written information, forms, or other information students will need in order to complete one or more of the assignment and/or job sheets. Students are not directly tested over the information presented in a supplement; however, their ability to apply this information may be evaluated in the completion of assignment sheets or job sheets.

Assignment sheets (Color code: Tan)

Assignment sheets provide students with pencil and paper activities that give students the opportunity to make practical application of the knowledge in the information sheet. Criteria are provided to objectively evaluate student performance.

Job sheets (Color code: Blue)

The job sheets provide criteria to objectively evaluate student performance, a list of required equipment and materials, and a step-by-step procedure for performing a psychomotor skill. The teacher should discuss the equipment and materials available in the classroom and/or laboratory and demonstrate the procedure prior to having students practice procedure. When a student is ready to be evaluated, the teacher should follow instructions for evaluating student performance which may be found in the teacher guide.

Job sheets are an important segment of each unit. Job sheets provide potential employers with a picture of the skills being taught during training and the performances that might reasonably be expected from an individual who has had this training.

Disseminating material

Material may be given out a unit or page at a time to keep the material before the student always new. Some teachers ask students to furnish a three-ring binder or folder for the current unit of study. This is convenient for students taking the material home to study. Upon completion, each unit is then placed in a larger binder. Some teachers prefer to store the material by unit in filing cabinets or boxes until needed.

For best results, provide student materials for each student. Student manuals contain objective sheets, information sheets, student supplements, assignment sheets, and job sheets. Students should be allowed to take their materials home at the end of the course.

Academic and Workplace Skills
(Classifications and Definitions)

Skill Groups	Sub Skills	Definitions
Learning Skills	Learning to learn	Developing ability to apply knowledge to other situations; knowing how to learn.
Foundation Skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
	Writing	Communicating a thought, idea or fact in written form in a clear, concise manner.
	Math	Applying computation skills such as reasoning, estimation, and problem solving as they are actually used on the job.
	Science	Applying knowledge learned through study or practice that is based on scientific principles as they relate to specific tasks.
Communication Skills	Listening	Listening for content, conversation, long-term contexts, emotional meaning, and directions.
	Oral communication	Communicating a thought, idea, or fact in spoken form in a clear, concise manner.
Adaptability Skills	Creative thinking	Using imagination to create something new—i.e. an idea, invention, work of art.
	Problem solving (critical thinking)	Recognizing and defining problems, inventing, and implementing solutions, and tracking and evaluating results.
Personal Management Skills	Self-esteem	Developing self-confidence and creating a positive self-image.
	Motivation/goal setting	Setting and meeting defined goals and objectives.
	Personal and career development	Emphasizing self-direction by establishing and implementing a plan.
Group Effectiveness Skills	Interpersonal relations	Developing ability to maintain positive relations with others.
	Negotiation	Resolving conflict between two or more individuals.
	Teamwork	Working together in a group to reach a common goal.
Influence Skills	Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.
	Leadership	Directing/influencing group in performance of a specific task; accepting responsibility for others.

Shielded Metal Arc Welding, Second Edition

Competency Profile

Name: ______________________________

Directions: Evaluate the student using the rating scale below. Write the appropriate number to indicate the degree of competency achieved. The descriptions associated with each of the numbers focuses on a level of student performance for each of the tasks listed. The written test scoreline is provided for optional teacher use. It may not be applicable in all cases.

Option A

Rating scale:
4 - Skilled - Can perform job with no additional training.
3 - Moderately Skilled - Has performed job during training program; limited additional training may be required.
2 - Limited Skill - Has performed job during training program; additional training is required to develop skill.
1 - Unskilled - Is familiar with process, but is unable to perform job.
0 - No Exposure - No information or practice provided during training program, complete training required.
NA - Non-applicable.

Option B

Yes - Can perform with no additional training
No - Is unable to perform satisfactorily

Unit 1: Safety

______ 1. Solve problems about shielded metal arc welding safety.
______ 2. ____

______Written Test Score

Unit 2: Equipment, Applications, and Techniques

______ 1. Start and restart an arc, crater, and backfill at the edge while running a bead on mild steel plate.
______ 2. Build a pad on mild steel plate in the flat position with an E6010 electrode.
______ 3. Build a pad on mild steel plate in the flat position with an E7018 electrode.
______ 4. Weld to specifications a fillet weld lap joint in the flat position with an E6010 electrode.
______ 5. Weld to specifications a multipass fillet weld on a T-joint in the flat position with an E6010 electrode.
______ 6. Weld to specifications a fillet weld lap joint in the flat position with an E7018 electrode.
______ 7. Weld to specifications a multipass fillet weld on a T-joint in the flat position with an E7018 electrode.
______ 8. Weld to specifications a fillet weld lap joint in the flat position with an E7024 electrode.

Competency Profile

_______ 9. Weld to specifications a multipass fillet weld on a T-joint in the flat position with an E7024 electrode.
_______10. Weld to specifications a fillet weld lap joint in the horizontal position with an E6010 electrode.
_______11. Weld to specifications a multipass fillet weld on a T-joint in the horizontal position with an E6010 electrode.
_______12. Weld to specifications a fillet weld lap joint in the horizontal position with an E7018 electrode.
_______13. Weld to specifications a multipass fillet weld on a T-joint in the horizontal position with an E7018 electrode.
_______14. Weld to specifications a fillet weld lap joint in the horizontal position with an E7024 electrode.
_______15. Weld to specifications a multipass fillet weld on a T-joint in the horizontal position with an E7024 electrode.
_______16. Weld to specifications a fillet weld lap joint in the vertical position with an E6010 electrode.
_______17. Weld to specifications a multipass fillet weld on a T-joint in the vertical positions with an E6010 electrode.
_______18. Weld to specifications a fillet weld lap joint in the vertical positions with an E7018 electrode.
_______19. Weld to specifications a multipass fillet weld on a T-joint in the vertical positions with an E7018 electrode.
_______20. Weld to specifications a fillet weld lap joint in the overhead position with an E6010 electrode.
_______21. Weld to specifications a multipass fillet weld on a T-joint in the overhead position with an E6010 electrode.
_______22. Weld to specifications a fillet weld lap joint in the overhead position with an E7018 electrode.
_______23. Weld to specifications a multipass fillet weld on a T-joint in the overhead position with an E7018 electrode.
_______24. Weld to specifications a V-groove butt joint in the flat position with an E6010 electrode.
_______25. Bend test a welded V-groove joint.
_______26. Weld to specifications a V-groove butt joint in the horizontal position with an E6010 electrode.
_______27. Weld to specifications a V-groove butt joint in the vertical position with an E6010 electrode.
_______28. Weld to specifications a V-groove butt joint in the overhead position with an E6010 electrode.
_______29. Weld to specifications a V-groove butt joint in the flat position with an E6010 electrode root and an E7018 electrode fill and cap.
_______30. Weld to specifications a V-groove butt joint in the horizontal position with an E6010 electrode root and an E7018 electrode fill and cap.
_______31. Weld to specifications a V-groove butt joint in the vertical position with an E6010 electrode root and an E7018 electrode fill and cap.
_______32. Weld to specifications a V-groove butt joint in the overhead position with an E6010 electrode root and an E7018 electrode fill and cap.
_______33. Weld to specifications an open-root corner joint in the flat position with an E6010 electrode.

Competency Profile

______34. Weld to specifications an open-root corner joint in the horizontal position with an E6010 electrode.
______35. Weld to specifications an open-root corner joint in the vertical position with an E6010 electrode.
______36. Weld to specifications an open-root corner joint in the overhead position with an E6010 electrode.
______37. Gouge a piece of mild steel with the air carbon arc cutting process.
______38. ______________________________

______Written Test Score

COMMENTS: ______________________________

____

____

____

____

Evaluator: ______________________ Date: ______________

***Permission to duplicate this profile is granted.**

Shielded Metal Arc Welding, Second Edition

Instructional/Task Analysis

Unit 1: Safety

Related Information: What the Student Should Know	Application: What the Student Should Be Able to Do
1. Terms and definitions	10. Solve problems about shielded metal arc welding safety
2. Electrical safety for arc welding	
3. Rules for handling welding cables	
4. Rules for handling hollow castings and containers	
5. Hazards from arc ray	
6. Types of welding hoods	
7. Steps in selecting a safe lens shade for shielded metal arc welding	
8. Protective clothing required for arc welding	
9. Environmental problems and their safety requirements	

Unit 2: Equipment, Applications, and Techniques

Related Information: What the Student Should Know	Application: What the Student Should Be Able to Do
1. Terns and definitions	
2. Advantages of SMAW	
3. Principles of SMAW	
4. Relationship of arc, base metal, electrodes, and flux	
5. Elements of flux-covered electrode functions	
6. Benefits of learning SMAW	
7. Welding machines and their electrical characteristics	

Related Information: What the Student Should Know	Application: What the Student Should Be Able to Do
8. Welding machines and their performance characteristics	
9. SMAW accessories and their purposes	
10. ASW electrode classifications for mild steel and low-alloy electrodes	
11. Stainless steel and other alloy electrodes	
12. Basic elements of arc welding and their importance	
13. Electrode angles	
14. SMAW starting techniques	
15. Controlling arc gap	
16. Techniques for using electrode angles	
17. Bead running techniques and their procedures	
18. Techniques for stopping and restarting an arc	
19. Techniques for filling a crater at the end of a weld	
20. Using feathered edges for tie-ins	
21. Basic steps in joint preparation	
22. Good and bad welds and their characteristics	
23. Causes of and remedies for arc blow	
24. Causes of and remedies for pinholes and porosity	

Related Information: What the Student Should Know

25. Causes of and remedies for undercutting
26. Causes of and remedies for weld splatter
27. Causes of and remedies for incomplete penetration
28. Cause of and remedies for slag inclusion
29. Causes of and remedies for excessive weld reinforcement
30. Principles of air carbon arc cutting
31. CAC-A power sources
32. CAC-A electrodes and their characteristics
33. CAC-A electrodes shapes and their uses
34. CAC-A electrode angles and their uses
35. Amperage selection for gouging
36. Air pressure and how it affects gouging
37. Travel speed and how it affects gouging
38. Techniques for gouging
39. Hardfacing
40. Elements affecting hardfacing
41. Electrode drying ovens

Application: What the Student Should Be Able to Do

42. Start and restart an arc, crater, and backfill at the edge while running a bead on mild steel plate. (Job Sheet 1)
43. Build a pad on mild steel plate in the flat position with an E6010 electrode. (Job Sheet 2)
44. Build a pad on mild steel plate in the flat position with an E7018 electrode. (Job Sheet 3)
45. Weld to specifications a fillet weld lap joint in the flat position with an E6010 electrode. (Job Sheet 4)
46. Weld to specifications a multipass fillet weld on a T-joint in the flat position with an E6010 electrode. (Job Sheet 5)
47. Weld to specifications a fillet weld lap joint in the flat position with an E7018 electrode. (Job Sheet 6)
48. Weld to specifications a multipass fillet weld on a T-joint in the flat position with an E7018 electrode. (Job Sheet 7)
49. Weld to specifications a fillet weld lap joint in the flat position with an E7024 electrode. (Job Sheet 8)
50. Weld to specifications a multipass fillet weld on a T-joint in the flat position with an E7024 electrode. (Job Sheet 9)
51. Weld to specifications a fillet weld lap joint in the horizontal position with an E6010 electrode. (Job Sheet 10)

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

52. Weld to specifications a multipass fillet weld on a T-joint in the horizontal position with an E6010 electrode. (Job Sheet 11)

53. Weld to specifications a fillet weld lap joint in the horizontal position with an E7018 electrode. (Job Sheet 12)

54. Weld to specifications a multipass fillet weld on a T-joint in the horizontal position with an E7018 electrode. (Job Sheet 13)

55. Weld to specifications a fillet weld lap joint in the horizontal position with an E7024 electrode. (Job Sheet 14)

56. Weld to specifications a multipass fillet weld on a T-joint in the horizontal position with an E7024 electrode. (Job Sheet 15)

57. Weld to specifications a fillet weld lap joint in the vertical position with an E6010 electrode. (Job Sheet 16)

58. Weld to specifications a multipass fillet weld on a T-joint in the vertical position with an E6010 electrode. (Job Sheet 17)

59. Weld to specifications a fillet weld lap joint in the vertical position with an E7018 electrode. (Job Sheet 18)

60. Weld to specifications a multipass fillet weld on a T-joint in the vertical position with an E7018 electrode. (Job Sheet 19)

61. Weld to specifications a fillet weld lap joint in the overhead position with an E6010 electrode. (Job Sheet 20)

Related Information: What the Student Should Know	Application: What the Student Should Be Able to Do
	62. Weld to specifications a multipass fillet weld on a T-joint in the overhead position with an E6010 electrode. (Job Sheet 21)
	63. Weld to specifications a fillet weld lap joint in the overhead position with an E7018 electrode. (Job Sheet 22)
	64. Weld to specifications a multipass fillet weld on a T-joint in the overhead position with an E7018 electrode. (Job Sheet 23)
	65. Weld to specifications a V-groove butt joint in the flat position with an E6010 electrode. (Job Sheet 24)
	66. Bend test a welded V-groove joint. (Job Sheet 25)
	67. Weld to specifications a V-groove butt joint in the horizontal position with an E6010 electrode. (Job Sheet 26)
	68. Weld to specifications a V-groove butt joint in the vertical position with an E6010 electrode. (Job Sheet 27)
	69. Weld to specifications a V-groove butt joint in the overhead position with an E6010 electrode. (Job Sheet 28)
	70. Weld to specifications a V-groove butt joint in the flat position with an E6010 electrode root and an E7018 electrode fill and cap. (Job Sheet 29)
	71. Weld to specifications a V-groove butt joint in the horizontal position with an E6010 electrode root and an E7018 electrode fill and cap. (Job Sheet 30)

Related Information: What the Student Should Know	**Application: What the Student Should Be Able to Do**
	72. Weld to specifications a V-groove butt joint in the vertical position with an E6010 electrode root and an E7018 electrode fill and cap. (Job Sheet 31)
	73. Weld to specifications a V-groove butt joint in the overhead position with an E6010 electrode root and an E7018 electrode fill and cap. (Job Sheet 32)
	74. Weld to specifications an open-root corner joint in the flat position with an E6010 electrode. (Job Sheet 33)
	75. Weld to specifications an open-root corner joint in the horizontal position with an E6010 electrode. (Job Sheet 34)
	76. Weld to specifications a an open-root corner joint in the vertical position with an E6010 electrode. (Job Sheet 35)
	77. Weld to specifications an open-root corner joint in the overhead position with an E6010 electrode. (Job Sheet 36)
	78. Gouge a piece of mild steel with the air carbon arc cutting process. (Job Sheet 37)

Related Academic and Workplace Skills
For *Shielded Metal Arc Welding, Second Edition*

Task	Skill Group	Sub Skill	Description
Unit 1: Safety			
Solve problems about shielded metal arc welding safety (A.S. 1)	Foundation Skills	Reading	Analyzes written information
	Adaptability Skills	Problem Solving (Critical Thinking)	Recognizes problems and creates effective solutions for them
Unit 2: Equipment, Applications, and Techniques			
Start and restart an a.c. crater, and backfill at the edge while running a bead on mild steel plate. (J.S. 1)	Foundation Skills	Reading	Comprehends written information and applies it to a task
		Science	Applies knowledge learned through practice to operate a machine and complete a process
Build a pad on mild steel plate in the flat position with an E6010 electrode. (J.S. 2)	Foundation Skills	Reading	Comprehends written information and applies it to a task
		Science	Applies knowledge learned through practice to operate a machine and complete a process
Build a pad on mild steel plate in the flat position with an E7018 electrode. (J.S. 3)	Foundation Skills	Reading	Comprehends written information and applies it to a task
		Science	Applies knowledge learned through practice to operate a machine and complete a process
Weld to specifications a fillet weld lap joint in the flat position with an E6010 electrode. (J.S. 4)	Foundation Skills	Reading	Comprehends written specifications and applies them to a task
		Science	Adapts welding skills to complete a fillet weld on a lap joint in the flat position

Task	Skill Group	Sub Skill	Description
Weld to specifications a multipass fillet weld on a T-joint in the flat position with an E6010 electrode. (J.S. 5)	Foundation Skills	Reading	Comprehends written specifications and applies them to a task
		Science	Adapts welding skills to complete a multipass fillet weld on a T-joint in the flat position
Weld to specifications a fillet weld lap joint in the flat position with an E7018 electrode. (J.S. 6)	Foundation Skills	Reading	Comprehends written specifications and applies them to a task
		Science	Adapts welding skills to complete a fillet weld on a lap joint in the flat position
Weld to specifications a multipass fillet weld on a T-joint in the flat position with an E7018 electrode. (J.S. 7)	Foundation Skills	Reading	Comprehends written specifications and applies them to a task
		Science	Adapts welding skills to complete a multipass fillet weld on a T-joint in the flat position
Weld to specifications a fillet weld lap joint in the flat position with an E7024 electrode. (J.S. 8)	Foundation Skills	Reading	Comprehends written specifications and applies them to a task
		Science	Adapts welding skills to complete a fillet weld on a lap joint in the flat position
Weld to specifications a multipass fillet weld on a T-joint in the flat position with an E7024 electrode. (J.S. 9)	Foundation Skills	Reading	Comprehends written specifications and applies them to a task
		Science	Adapts welding skills to complete a multipass fillet weld on a T-joint in the flat position
Weld to specifications a fillet weld lap joint in the horizontal position with an E6010 electrode. (J.S. 10)	Foundation Skills	Reading	Comprehends written specifications and applies them to a task
		Science	Adapts welding skills to complete a fillet weld on a lap joint in the horizontal position

Task	Skill Group	Sub Skill	Description
Weld to specifications a multipass fillet weld on a T-joint in the horizontal position with an E6010 electrode. (J.S. 11)	Foundation Skills	Reading	Comprehends written specifications and applies them to a task
		Science	Adapts welding skills to complete a multipass fillet weld on a T-joint in the horizontal position
Weld to specifications a fillet weld lap joint in the horizontal position with an E7018 electrode. (J.S. 12)	Foundation Skills	Reading	Comprehends written specifications and applies them to a task
		Science	Adapts welding skills to complete a fillet weld on a lap joint in the horizontal position
Weld to specifications a multipass fillet weld on a T-joint in the horizontal position with an E7018 electrode. (J.S. 13)	Foundation Skills	Reading	Comprehends written specifications and applies them to a task
		Science	Adapts welding skills to complete a multipass fillet weld on a T-joint in the horizontal position
Weld to specifications a fillet weld lap joint in the horizontal position with an E7024 electrode. (J.S. 14)	Foundation Skills	Reading	Comprehends written specifications and applies them to a task
		Science	Adapts welding skills to complete a fillet weld on a lap joint in the horizontal position
Weld to specifications a multipass fillet weld on a T-joint in the horizontal position with an E7024 electrode. (J.S. 15)	Foundation Skills	Reading	Comprehends written specifications and applies them to a task
		Science	Adapts welding skills to complete a multipass fillet weld on a T-joint in the horizontal position
Weld to specifications a fillet weld lap joint in the vertical position with an E6010 electrode. (J.S. 16)	Foundation Skills	Reading	Comprehends written specifications and applies them to a task
		Science	Adapts welding skills to complete a fillet weld on a lap joint in the vertical position

Task	Skill Group	Sub Skill	Description
Weld to specifications a multipass fillet weld on a T-joint in the vertical positions with an E6010 electrode. (J.S. 17)	Foundation Skills	Reading	Comprehends written specifications and applies them to a task
		Science	Adapts welding skills to complete a multipass fillet weld on a T-joint in the vertical position
Weld to specifications a fillet weld lap joint in the vertical positions with an E7018 electrode. (J.S. 18)	Foundation Skills	Reading	Comprehends written specifications and applies them to a task
		Science	Adapts welding skills to complete a fillet weld on a lap joint in the vertical position
Weld to specifications a multipass fillet weld on a T-joint in the vertical positions with an E7018 electrode. (J.S. 19)	Foundation Skills	Reading	Comprehends written specifications and applies them to a task
		Science	Adapts welding skills to complete a multipass fillet weld on a T-joint in the vertical position
Weld to specifications a fillet weld lap joint in the overhead position with an E6010 electrode. (J.S. 20)	Foundation Skills	Reading	Comprehends written specifications and applies them to a task
		Science	Adapts welding skills to complete a fillet weld on a lap joint in the overhead position
Weld to specifications a multipass fillet weld on a T-joint in the overhead position with an E6010 electrode. (J.S. 21)	Foundation Skills	Reading	Comprehends written specifications and applies them to a task
		Science	Adapts welding skills to complete a multipass fillet weld on a T-joint in the overhead position
Weld to specifications a fillet weld lap joint in the overhead position with an E7018 electrode. (J.S. 22)	Foundation Skills	Reading	Comprehends written specifications and applies them to a task
		Science	Adapts welding skills to complete a fillet weld on a lap joint in the overhead position

Task	Skill Group	Sub Skill	Description
Weld to specifications a multipass fillet weld on a T-joint in the overhead position with an E7018 electrode. (J.S. 23)	Foundation Skills	Reading	Comprehends written specifications and applies them to a task
		Science	Adapts welding skills to complete a multipass fillet weld on a T-joint in the overhead position
Weld to specifications a V-groove butt joint in the flat position with an E6010 electrode. (J.S. 24)	Foundation Skills	Reading	Comprehends written specifications and applies them to a task
		Math	Measures and cuts an angle to specifications
		Science	Adapts welding skills to complete a V-groove butt joint in the flat position
Bend test a welded V-groove joint. (J.S. 25)	Foundation Skills	Reading	Comprehends written information and applies it to a task
		Math	Measures and cuts an angle to specifications
		Science	Applies knowledge learned through practice to operate a machine and complete a process
Weld to specifications a V-groove butt joint in the horizontal position with an E6010 electrode. (J.S. 26)	Foundation Skills	Reading	Comprehends written specifications and applies them to a task
		Math	Measures and cuts an angle to specifications
		Science	Adapts welding skills to complete a V-groove butt joint in the horizontal position
Weld to specifications a V-groove butt joint in the vertical positions with an E6010 electrode. (J.S. 27)	Foundation Skills	Reading	Comprehends written specifications and applies them to a task
		Math	Measures and cuts an angle to specifications
		Science	Adapts welding skills to complete a V-groove butt joint in the vertical position

Task	Skill Group	Sub Skill	Description
Weld to specifications a V-groove butt joint in the overhead position with an E6010 electrode. (J.S. 28)	Foundation Skills	Reading	Comprehends written specifications and applies them to a task
		Math	Measures and cuts an angle to specifications
		Science	Adapts welding skills to complete a V-groove butt joint in the overhead position
Weld to specifications a V-groove butt joint in the flat position with an E6010 electrode root and an E7018 electrode fill and cap. (J.S. 29)	Foundation Skills	Reading	Comprehends written specifications and applies them to a task
		Math	Measures and cuts an angle to specifications
		Science	Adapts welding skills to complete a V-groove butt joint in the overhead position
Weld to specifications a V-groove butt joint in the horizontal position with an E6010 electrode root and an E7018 electrode fill and cap. (J.S. 30)	Foundation Skills	Reading	Comprehends written specifications and applies them to a task
		Math	Measures and cuts an angle to specifications
		Science	Adapts welding skills to complete a V-groove butt joint in the horizontal position
Weld to specifications a V-groove butt joint in the vertical positions with an E6010 electrode root and an E7018 electrode fill and cap. (J.S. 31)	Foundation Skills	Reading	Comprehends written specifications and applies them to a task
		Math	Measures and cuts an angle to specifications
		Science	Adapts welding skills to complete a V-groove butt joint in the vertical position

Task	Skill Group	Sub Skill	Description
Weld to specifications a V-groove butt joint in the overhead position with an E6010 elec-trode root and an E7018 electrode fill and cap. (J.S. 32)	Foundation Skills	Reading	Comprehends written specifications and applies them to a task
		Math	Measures and cuts an angle to specifications
		Science	Adapts welding skills to complete a V-groove butt joint in the overhead position
Weld to specifications an open-root corner joint in the flat position with an E6010 electrode. (J.S. 33)	Foundation Skills	Reading	Comprehends written specifications and applies them to a task
		Science	Adapts welding skills to complete an open-root corner joint in the flat position
Weld to specifications an open-root corner joint in the horizontal position with an E6010 electrode. (J.S. 34)	Foundation Skills	Reading	Comprehends written specifications and applies them to a task
		Science	Adapts welding skills to complete an open-root corner joint in the horizontal position
Weld to specifications an open-root corner joint in the vertical positions with an E6010 electrode. (J.S. 35)	Foundation Skills	Reading	Comprehends written specifications and applies them to a task
		Science	Adapts welding skills to complete an open-root corner joint in the vertical position
Weld to specifications an open-root corner joint in the overhead position with an E6010 electrode. (J.S. 36)	Foundation Skills	Reading	Comprehends written specifications and applies them to a task
		Science	Adapts welding skills to complete an open-root corner joint in the overhead position
Gouge a piece of mild steel with the air carbon arc cutting process. (J.S. 37)	Foundation Skills	Reading	Comprehends written information and applies it to a task
		Science	Applies knowledge learned through practice to operate a machine and complete a process

Tools, Equipment, and Materials List

Assortment of welding lens shades
Bench vise
Chipping hammer
Face shield
File
Fire extinguisher
Fitter's hammer
Gouging equipment complete with compressed air supply and gouging electrodes
Ground clamp
Hand-held grinder
Mild steel plate
Personal safety clothing
Pliers
Safety glasses
SMAW electrode and work leads
SMAW electrode holder
SMAW electrodes: E6010, E7018, E7024, and others at instructor's option
SMAW welding machine
Spring clamp
Welding helmet
Wire brush
Work station shielding screens

Shielded Metal Arc Welding, Second Edition

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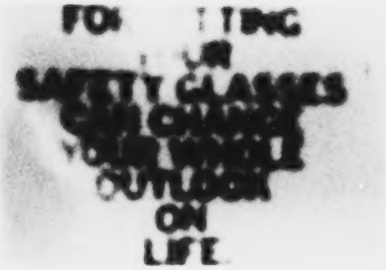
The Procedure Handbook of Arc Welding, Twelfth Edition. Cleveland, OH: The Lincoln Electric Company, 1973.

Welding & Fabricating Data Book, 1988/89. Cleveland, OH: Penton Publishing Inc., 1988.

Welding Power Handbook. New York: Union Carbide Corporation, Linde Division, 1973.



Safety
Unit 1

Objective Sheet

Unit Objective

After completing this unit, the student should be able to define welding hoods, lens shades, and protective clothing required for safety in the welding workplace. The student should also be able to solve problems about shielded metal arc welding safety. The student should demonstrate these competencies by completing the assignment sheet and by scoring 100 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to shielded metal arc welding safety with their correct definitions.
2. Select true statements concerning electrical safety for arc welding.
3. Complete statements about rules for handling welding cables.
4. Complete statements about rules for handling hollow castings and containers.
5. Select solutions for hazards from arc rays.
6. Differentiate between types of welding hoods.
7. Complete a list of steps in selecting a safe lens shade for shielded metal arc welding.
8. Solve problems about protective clothing required for arc welding.
9. Solve problems about environmental problems and their safety requirements.
10. Solve problems about shielded metal arc welding safety. (Assignment Sheet 1)

Safety
Unit 1

Suggested Activities

Instructional Plan

Preparation

1. Read unit carefully and plan for instruction.

2. Review Teaching Suggestions section that follows. Plan for classroom activities.

3. Plan for enrichment of exceptional students as well as accommodation of special needs students.

4. Obtain films, videotapes, and other resources to supplement instruction of this unit. See ordering information in the Suggested Supplemental Resources section that follows.

5. Develop teaching plan. Adjust for different learning styles.

6. Make copies of Unit Evaluation Form.

Delivery and Application

7. Provide students with unit of instruction.

8. Discuss unit and specific objectives

9. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.

10. Discuss the assignment sheet. Review criteria for evaluation of this activity.

Evaluation

11. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.

12. Make copies of the written test.

13. Given written test.

14. Compile assignment sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignments.

15. Reteach and retest as required.

Suggested Activities

Teaching Suggestions

Note: Skill areas appearing in bold face type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These have been adapted by MAVCC.

1. Give students a tour of the facilities in which they will be working. Point out the location of fire extinguishers, excape routes in the event of a fire, and other elements related to safety in the workplace.

2. Invite a local welding shop owner or contractor to talk to the class about working in situations that pose added risks or hazards, jobs that require welding in high places, welding in confined spaces, or welding in outdoor areas where property and people should both be a prime concern of the welder.

Resources Used in Developing This Unit

1. Fortney, Clarence and Mike Gregory. *SMAW Shielded Metal Arc Welding.* Stillwater, OK: The Mid-America Vocational Curriculum Consortium, 1984.

2. *Precautions and Safe Practices for Electric Welding and Cutting.* New York: Union Carbide Corporation, Linde Division, 1980.

3. *Welding & Fabricating Data Book*, 1988/89. Cleveland, OH: Penton Publishing Inc., 1988.

4. *OSHA Safety and Health Standards (29 CFR 1910) Revised.* Washington, DC: U.S. Department of Labor, Occupational Safety and Health Administration, 1981.

5. Connor, Leonard, P., ed. *Welding Handbook Eighth Edition, Vol. 1, Welding Technology.* Miami, FL: The American Welding Society, 1987.

6. O'Brien, R. L., ed. *Welding Handbook Eighth Edition, Vol. 2, Welding Processes.* Miami, FL: American Welding Society, 1991.

Suggested Activities

Suggested Supplemental Resources

1. Several printed publications are available from the American Welding Society. They include *Arc Welding and Cutting Noise* and *Arc Welding Safety*. The safety publication is also available in the Spanish language version, *Seguridad en la Soldadura por Arco*. Instructors at educational institutions may purchase items from AWS with an appreciable educational discount. For ordering information, call 1-800-334-9353 or write to:

   Order Department
   American Welding Society
   550 Northwest LeJeune Road
   P.O. Box 351040
   Miami, FL 33135

2. Another item available from AWS is a video tape produced by the National Electrical Manufacturers Association. It presents necessary safety precautions for everyone involved in welding. Titled *Welding Safely — The Way The Pros Do It*, the tape is available in a ½" VHS format. For information call the number or write to the address given above.

Answers to Assignment Sheet

Assignment Sheet 1

Note: Student answers should approximate those given.

a. Yes. The welding machine should be disconnected from the power source.
b. Yes. Only a dry rag should be used to clean a welding cable.
c. Yes. Erect a shielding curtain or panel around the work area.
d. Yes. Use a minimum #8 lens shade and take a position that will provide better visibility.
e. Yes. A welding cap pulled down over the left ear would eliminate the hazard.
f. Yes. A face shield should also be worn when grinding.

Safety
Unit 1

Answers to Written Test

1. a. 2
   b. 3
   c. 1

2. a, b, c, d, e, f, g, h, i, j

3. a. Oil; an obstruction
   b. Clean, dry rags; an oily rag
   c. Kinks; on a flat surface off the floor
   d. Gas cylinder

4. a. Vented
   b. Should not be
   c. Hollow castings or containers

5. a. 2
   b. 3

6. a. F
   b. S

7. a. Electrode
   b. #8
   c. Higher

8. a. 2
   b. 1
   c. 2
   d. 2

9. a. 2
   b. 3

Safety
Unit 1

Written Test

Name ______________________________ Score ______________

1. Match the terms on the right with their correct definitions.

_______a. A reduction of oxygen caused by any arc or flame in the work zone around a welding activity

_______b. Poisonous gases, fumes, and vapors produced by chemical reactions in certain welding processes

_______c. Impurities formed from chemical reactions between base metals, flux, and electrodes

1. Contaminants
2. Oxygen displacement
3. Toxic hazards

2. Select true statements concerning electrical safety for arc welding. Place an "X" beside each true statement.

_______a. All electrical equipment should have an earth ground for safety reasons, and this ground should not be confused with the work lead to workpiece ground that completes the welding circuit.

_______b. Keep electrical connections tight, clean, and dry because poor connections can heat up, cause bad welds, produce dangerous arcs and sparking, and even melt.

_______c. Keep work area, equipment, and clothing dry because even a slight amount of moisture can conduct enough electricity to cause a severe shock.

_______d. Never dip an electrode holder in water to cool it.

_______e. When working with welding machines set up for multiple operation, be very careful not to touch hot parts of the electrode holders because open-circuit voltages from two machines are increased and can cause a severe shock.

_______f. Remove electrode from electrode holder when work is finished.

_______g. Disconnect and lock out all electric power sources before doing any work on electrical equipment.

Written Test

______h. When working in high places, carefully examine work area for electrical hazards because a shock in such conditions could cause a fall and severe injury.

______i. Keep welding cables free of conduits, motors, and any other equipment that could cause a short circuit.

______j. Keep ground as far away from the arc as possible.

3. Complete statements about rules for handling welding cables. Circle the information that best completes each statement.

    a. Never drag a welding cable through (dirt) (oil) and never pull on a cable to force it over (an obstruction) (a welding machine).

    b. Use only (rags dipped in cleaning solvent) (clean, dry rags) to clean welding cables and never use gasoline or (a wet rag) (an oily rag) to clean a cable.

    c. When not in use, keep welding cables free of (dirt) (kinks) and properly stored (on a peg on a wall) (on a flat surface off the floor).

    d. Never drape a welding cable over any type of (gas cylinder) (metal).

4. Complete statements about rules for handling hollow castings and containers. Circle the information that best completes each of the following statements.

    a. Hollow castings or containers should be (filled) (vented) before any heating, cutting, or welding activity.

    b. Tanks, drums, and containers (should not be) (can usually be) heated, cut, or welded.

    c. The rule for beginning welders is to never attempt heating, cutting, or welding on (hollow castings or containers) (barrels that have had solvent in them).

Written Test

5. Select solutions for hazards from arc rays. Circle the best response to each of the following conditions.

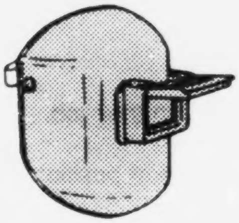
   a. A welder is arc welding and wearing a welding helmet, the right lens shade, and safety glasses, but the welder is in a short sleeve shirt.

      (1) The welder is safe so long as welding is done in a hurry.
      (2) The welder needs to have hands, arms, legs, and torso covered with durable flame-resistant clothing.
      (3) The welder needs gloves with extremely long gauntlets.

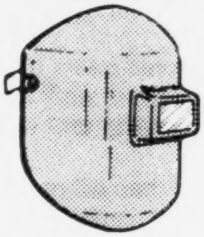
   b. The arc flash from an arc welding station is clearly visible to people who have to walk to the shop office.

      (1) People should be directed to take another route.
      (2) People should be given shaded-lens glasses.
      (3) The work area should have a shield around it to contain the arc flash.

6. Differentiate between types of welding hoods. Place an "S" beside the illustration of a stationary filter lens helmet and an "F" beside the flip-front filter lens helmet.



______a.



______b.

7. Complete a list of steps in selecting a safe lens shade for shielded metal arc welding. Circle the information that best completes each of the following statements.

   a. Determine electrode size and amperage range for the (electrode) (joint design).

   b. Select lens shade according to the lens manufacturer's selection chart, but never select less than a (#5) (#8) lens shade for shielded metal arc welding.

   c. A rule of thumb is that the larger the diameter of the electrode, the (lower) (higher) the number required for a lens shade.

Written Test

8. Solve problems about protective clothing required for arc welding. Select the best solution to each of the following scenarios.

   a. For a welding job where there would be a danger that flying sparks might strike a welder around the head and ear area, what could make the situation safe?

      (1) Moving the job to a safer area.
      (2) Make sure the welder wears an welder's cap underneath the welding helmet and turns the bill to protect the ear opening on the side where sparks might fall.
      (3) Take a different welding position.

   b. For a welding job that poses the danger that flying sparks and metal splatter might fall on a welder's legs, what could make the situation safer?

      (1) Wear heavy leather boots that reach above the ankle, and cuffless pants.
      (2) Wear good gloves.
      (3) Wear a welding jacket.

   c. For a welding job that poses danger from other construction materials falling from above, what could make the situation safer.

      (1) Build a covered frame over the welding area.
      (2) Have the welders wear hard hats.
      (3) Postpone welding until workers above have finished with their job.

   d. For a welding job that will require a welder to be welding out of position in a confined area, what could make the situation safer?

      (1) Have the welder move to another position.
      (2) Have the welder wear a leather jacket along with a welder's cap.
      (3) Have the welder wear a hard hat.

Written Test

9. Solve problems about environmental problems with their safety requirements. Circle the number of the best solution to each of the following problems.

   a. A welding workplace has the potential for generating dangerous and irritating smoke. To protect welders, the workplace should:

      (1) Have a fan positioned to blow the smoke away from the welders.
      (2) Have an exhaust system.
      (3) Be made open to outside air.

   b. A welder working on a job in a confined area stops because there are extremely irritating fumes in the area. Before work continues:

      (1) The welder should be given a filter-type mask to wear.
      (2) The welder should approach the work from a different angle.
      (3) The welder should be given an air-supplied respirator that can compensate for oxygen depletion in the confined area.

***Permission to duplicate this test is granted.**

Safety
Unit 1

Unit Evaluation Form

Student Name ______________________________ Unit Rating __________

Assignment Sheet 1—Solve Problems About Shielded Metal Arc Welding Safety Rating _____

Comments: ____

____

Written Test Scores

Pretest _____ Posttest _____ Other _____

Other ____

____

Teacher Signature ______________________________ Date __________

Student Signature ______________________________ Date __________

***Permission to duplicate this form is granted.**

Safety
Unit 1

Information Sheet

1. **Terms and definitions**

   a. **Oxygen displacement** — A reduction of oxygen caused by any arc or flame in the work zone around a welding activity

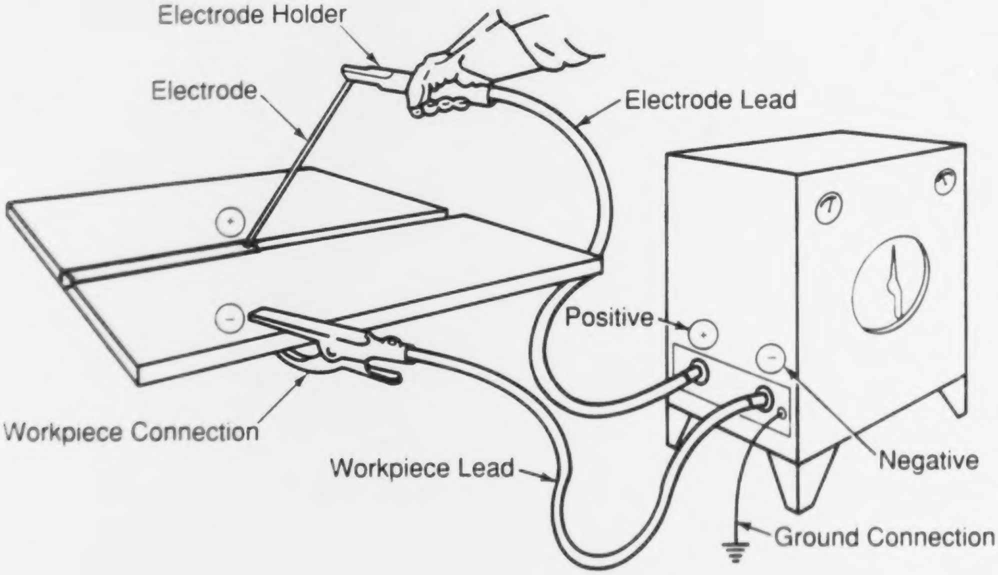
   b. **Toxic hazards** — Poisonous gases, fumes, and vapors produced by chemical reactions in certain welding processes

   c. **Contaminants** — Impurities formed from chemical reactions between base metals, flux, and electrodes, and usually present in fumes and vapors

   Caution: Toxic hazards and contaminants are usually present in fumes and vapors.

2. **Electrical safety for arc welding**

   a. All electrical equipment should have an earth ground for safety reasons, and this ground should not be confused with the work lead to workpiece ground that completes the welding circuit.


Electrode Holder
Electrode
Electrode Lead
+
−
Positive
+
−
Workpiece Connection
Workpiece Lead
Negative
Ground Connection

Courtesy American Welding Society

Information Sheet

b. Keep electrical connections tight, clean, and dry because poor connections can heat up, cause bad welds, produce dangerous arcs and sparking, and even melt.

c. Keep work area, equipment, and clothing dry because even a slight amount of moisture can conduct enough electricity to cause a severe shock.

d. Never dip an electrode holder in water to cool it.

e. When working with welding machines set up for multiple operation, be very careful not to touch hot parts of the electrode holders because open-circuit voltages from two machines are increased and can cause a severe shock.

f. Remove electrode from electrode holder when work is finished.

g. Disconnect and lock out all electric power sources before doing any work on electrical equipment.

h. When working in high places, carefully examine work area for electrical hazards because a shock in such conditions could cause a fall and severe injury.

i. Keep welding cables free of conduits, motors, and any other equipment that could cause a short circuit.

j. Keep ground as far away from the arc as possible.

3. **Rules for handling welding cables**

a. Never drag a welding cable through oil, and never pull on a cable to force it over an obstruction.

b. Use only clean, dry rags to clean welding cables, and never use gasoline or an oily rag to clean a cable.

c. When not in use, keep welding cables free of kinks and properly stored on a flat surface off the floor.

d. Never drape a welding cable over any type of gas cylinder.

4. **Rules for handling hollow castings or containers**

a. Hollow castings or containers should be vented before any heating, cutting, or welding activity.

b. Tanks, drums, and containers should not be heated, cut, or welded.

c. The rule for beginning welders is to never attempt heating, cutting, or welding on hollow castings or containers.

Information Sheet

5. **Hazards from arc rays**

   a. A welding arc produces ultraviolet and infrared radiation that can severely burn eyes that are unprotected with a proper shade of protective lens.

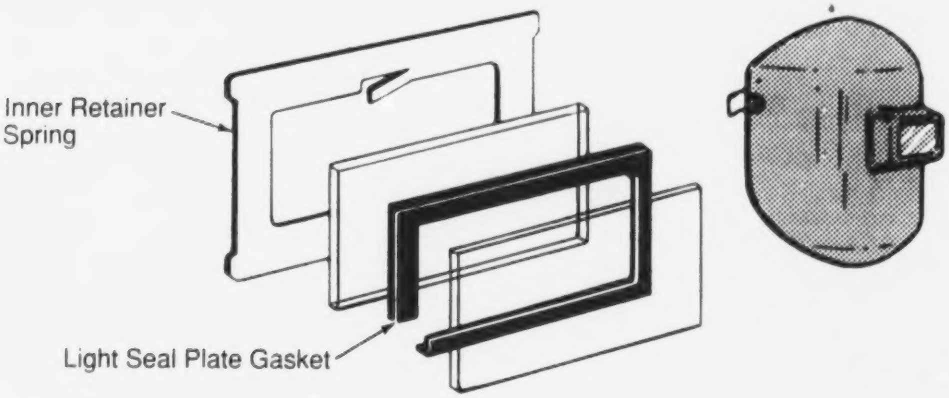
      Note: A welding helmet or hood protects the head from flying sparks, but the shaded lens and safety glasses are required for total eye protection.

   b. Radiation from a welding arc is strong enough to burn or sometimes blister bare skin if the exposure is intense or for an extended period, so arms, legs, and torso should be covered with durable flame-resistant clothing.

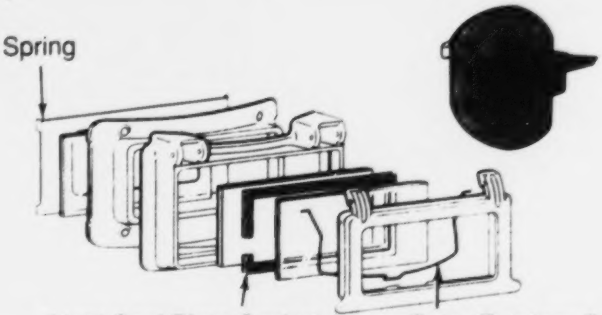
   c. Work stations and work areas should be shielded to prevent an arc flash from injuring nearby workers or visitors.

6. **Types of welding hoods**

   a. **Stationary filter lens** — This type hood has a fixed lens housing with the shaded lens held in by a spring retainer from where a lens can be slipped out and replaced as welding requires.



b. **Flip-front filter lens** — This type hood has a lens housing with a front side that can be flipped up so that it leaves a clear-glass lens that permits the hood to be worn while chipping.



7. **Steps in selecting a safe lens shade for shielded metal arc welding**

a. Determine the electrode size and amperage range for the electrode because electrode size and amperage used dictate the lens protection required.

b. Select lens shade according to the lens manufacturer's selection chart, but never select less than a #8 lens shade for shielded metal arc welding.

Note: When you remove your hood after arc welding and you see white spots or white blotches as after images, it means that you are getting too much light through the lens and you should switch to a shade at least one number darker, or check the seal on your lens.

Electrode Size	Amperage	Shade #
—	30 to 75	8
1/16 - 5/32	75 to 200	10
3/16 - 1/4	200 to 400	12
5/16 - 3/8	400 +	14

c. A rule of thumb is that the larger the diameter of the electrode, the higher the number required for a lens shade.

Information Sheet

8. Protective clothing required for arc welding

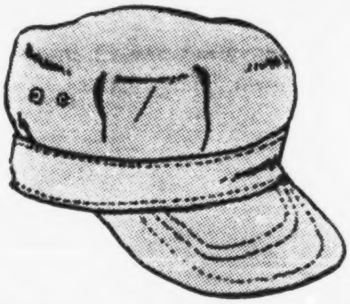
a. Basic clothing requirements:

(1) Heavy, long sleeve shirts with pocket flaps

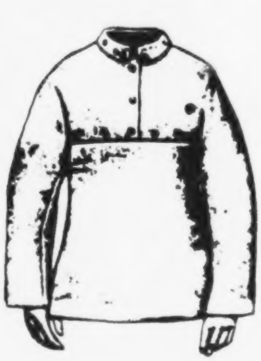
(2) Heavy, cuffless pants not frayed at the bottom

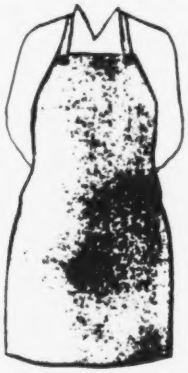
(3) No clothing made of synthentic materials

b. A welder's cap has a flexible bill that can be slipped around to cover either ear and keep sparks or metal splatter out of the ear opening.



c. Leather jackets and aprons should be worn for additional protection, especially when welding out of position or in confined areas where flying sparks present an increased hazard.



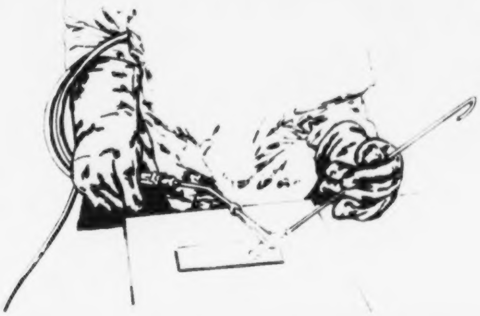


d. Boots should be made of heavy leather with uppers that reach above the ankle to help prevent burns from sparks and spatter.

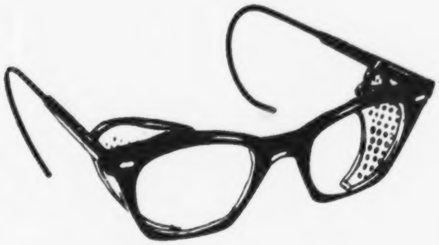
Note: Although steel-toed boots are not required, they are highly recommended.

Information Sheet

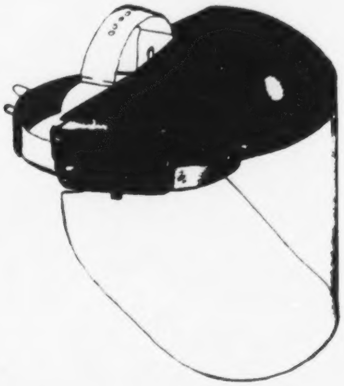
e. Heavy leather gloves with gauntlets are required for all welding and cutting activities.



f. Safety glasses should have nonmetal frames, and impact-resistant lenses with side shields to protect from flying objects.



g. To provide good visibility when chipping or grinding, wear a clear, plastic-type face shield because it will provide protection from slag or metal.

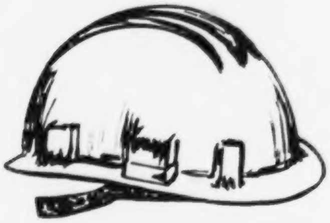


h. Wear a face shield when required, but do not substitute a face shield for safety glasses because safety glasses should be worn at all times in the welding workplace.

Information Sheet

i. In situations where the danger of falling materials or tools may be present, always wear a hard hat.

Note: In certain job situations, wearing a hard hat may be a requirement of the contractor.

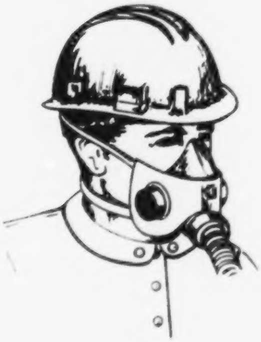


9. Environmental problems and their safety requirements

a. **Ventilation** — Many welding activities produce toxic fumes and vapors that are hazardous to breathe, and every work station should be equipped with ventilation or an exhaust system capable of safely removing dangerous and irritating smoke and contaminants.

Caution: Always position your head out of the way of rising fumes.

b. **Respirators** — In confined areas where the hazard of toxic fumes is increased, a welder should wear an air-supplied respirator or a self-contained breathing apparatus, not a filter-type mask that cannot compensate for oxygen displacement.



c. **Noise** — This is a workplace hazard frequently overlooked, but ear plugs or muffler-type ear protectors should be worn when the work area subjects a welder to high noise levels, especially high noise levels that are continuous.

Information Sheet

d. **Lighting** — Lighting in a work area or at a work station should be bright enough to provide good visibility free of glare because poorly lit work areas contribute to eye fatigue, irritation, and poor work.

Safety
Unit 1

Assignment Sheet 1—Solve Problems About Shielded Metal Arc Welding Safety

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Recognition of problems	______
Accuracy of solutions	______

Directions: Read the following scenarios carefully, then write a brief statement that recommends a specific solution if there is a safety violation presented.

a. A fellow student is attempting to replace a tension spring in an electrode clamp while the welding machine is still turned on. Is there a problem? ______________

Solution: ______________________________

____

b. A fellow student is attempting to clean a welding cable with an oily rag. Is there a problem? ______________________________

Solution: ______________________________

____

c. A fellow student is arc welding in an unshielded area that has several other students nearby. Is there a problem? ______________________________

Solution: ______________________________

____

d. A fellow student complains that she can't see to arc weld at 50 amps through a #8 lens shade, so she puts a #4 lens shade in her welding hood and starts to weld. Is there a problem? ______________________________

Solution: ______________________________

____

Assignment Sheet 1

e. A fellow student wearing a welding helmet is arc welding in such a position that there is danger that spatter and sparks will strike the left side of his face, which is uncovered. Is there a problem? ________________

Solution: ________________

____

f. A fellow student is grinding a sample weld and is wearing safety glasses. Is there a problem? ________________

Solution: ________________

____

Equipment, Applications, and Techniques
Unit 2

Objective Sheet

Unit Objective

After completing this unit, the student should be able to weld fillet and groove welds in all positions, test fillet and groove welds, and use air carbon arc cutting equipment to gouge mild steel plate. The student should demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to SMAW equipment, applications, and techniques with their correct definitions.
2. Select true statements about advantages of SMAW.
3. Complete statements about the principles of SMAW.
4. Solve problems about the relationship of arc, base metal, electrode, and flux.
5. Differentiate between elements of flux-covered electrode functions.
6. Select true statements about benefits of learning SMAW.
7. Match welding machines with their electrical characteristics.
8. Match welding machine performance characteristics with their applications.
9. Complete statements about basic SMAW accessories and their purposes.
10. Complete statements about AWS electrode classifications for mild steel and low alloy electrodes.
11. Differentiate between stainless steel and other alloy electrodes.
12. Complete statements about basic elements of arc welding and their importance.
13. Differentiate between electrode angles.

Objective Sheet

14. Differentiate between SMAW starting techniques.
15. Complete statements about techniques for controlling arc gap.
16. Complete statements about techniques for using electrode angles.
17. Match bead running techniques with their procedures.
18. Select true statements about the techniques for stopping and restarting an arc.
19. Complete statements about techniques for filling a crater at the end of a weld.
20. Select guidelines for using feathered edges for tie-ins.
21. Differentiate between basic steps in joint preparation.
22. Match good and bad welds with their characteristics.
23. Select causes of and remedies for arc blow.
24. Select causes of and remedies for pinholes and porosity.
25. Select causes of and remedies for undercutting.
26. Select causes of and remedies for weld spatter.
27. Select causes of and remedies for incomplete penetration.
28. Select causes of and remedies for slag inclusion.
29. Select causes of and remedies for excessive weld reinforcement.
30. Select true statements about the principles of air carbon arc cutting.
31. Select true statements about CAC-A power sources.
32. Match types of CAC-A electrodes with their characteristics.
33. Match CAC-A electrode shapes with their uses.
34. Match CAC-A electrode angles with their uses.
35. Complete statements about amperage selection for gouging.
36. Complete statements about air pressure and how it affects gouging.
37. Complete statements about travel speed and how it affects gouging.

Objective Sheet

38. Match techniques for gouging with their procedures.

39. Complete statements about hardfacing.

40. Select true statements about elements affecting hardfacing.

41. Complete statements about electrode drying ovens.

42. Start and restart an arc, crater, and backfill at the edge while running a bead on mild steel plate. (Job Sheet 1)

43. Build a pad on mild steel plate in the flat position with an E6010 electrode. (Job Sheet 2)

44. Build a pad on mild steel plate in the flat position with an E7018 electrode. (Job Sheet 3)

45. Weld to specifications a fillet weld lap joint in the flat position with an E6010 electrode. (Job Sheet 4)

46. Weld to specifications a multipass fillet weld on a T-joint in the flat position with an E6010 electrode. (Job Sheet 5)

47. Weld to specifications a fillet weld lap joint in the flat position with an E7018 electrode. (Job Sheet 6)

48. Weld to specifications a multipass fillet weld on a T-joint in the flat position with an E7018 electrode. (Job Sheet 7)

49. Weld to specifications a fillet weld lap joint in the flat position with an E7024 electrode. (Job Sheet 8)

50. Weld to specifications a multipass fillet weld on a T-joint in the flat position with an E7024 electrode. (Job Sheet 9)

51. Weld to specifications a fillet weld lap joint in the horizontal position with an E6010 electrode. (Job Sheet 10)

52. Weld to specifications a multipass fillet weld on a T-joint in the horizontal position with an E6010 electrode. (Job Sheet 11)

53. Weld to specifications a fillet weld lap joint in the horizontal position with an E7018 electrode. (Job Sheet 12)

54. Weld to specifications a multipass fillet weld on a T-joint in the horizontal position with an E7018 electrode. (Job Sheet 13)

Objective Sheet

55. Weld to specifications a fillet weld lap joint in the horizontal position with an E7024 electrode. (Job Sheet 14)

56. Weld to specifications a multipass fillet weld on a T-joint in the horizontal position with an E7024 electrode. (Job Sheet 15)

57. Weld to specifications a fillet weld lap joint in the vertical position with an E6010 electrode. (Job Sheet 16)

58. Weld to specifications a multipass fillet weld on a T-joint in the vertical position with an E6010 electrode. (Job Sheet 17)

59. Weld to specifications a fillet weld lap joint in the vertical position with an E7018 electrode. (Job Sheet 18)

60. Weld to specifications a multipass fillet weld on a T-joint in the vertical position with an E7018 electrode. (Job Sheet 19)

61. Weld to specifications a fillet weld lap joint in the overhead position with an E6010 electrode. (Job Sheet 20)

62. Weld to specifications a multipass fillet weld on a T-joint in the overhead position with an E6010 electrode. (Job Sheet 21)

63. Weld to specifications a fillet weld lap joint in the overhead position with an E7018 electrode. (Job Sheet 22)

64. Weld to specifications a multipass fillet weld on a T-joint in the overhead position with an E7018 electrode. (Job Sheet 23)

65. Weld to specifications a V-groove butt joint in the flat position with an E6010 electrode. (Job Sheet 24)

66. Bend test a welded V-groove joint. (Job Sheet 25)

67. Weld to specifications a V-groove butt joint in the horizontal position with an E6010 electrode. (Job Sheet 26)

68. Weld to specifications a V-groove butt joint in the vertical position with an E6010 electrode. (Job Sheet 27)

69. Weld to specifications a V-groove butt joint in the overhead position with an E6010 electrode. (Job Sheet 28)

70. Weld to specifications a V-groove butt joint in the flat position with an E6010 electrode root and an E7018 electrode fill and cap. (Job Sheet 29)

Objective Sheet

71. Weld to specifications a V-groove butt joint in the horizontal position with an E6010 electrode root and an E7018 electrode fill and cap. (Job Sheet 30)

72. Weld to specifications a V-groove butt joint in the vertical position with an E6010 electrode root and an E7018 electrode fill and cap. (Job Sheet 31)

73. Weld to specifications a V-groove butt joint in the overhead position with an E6010 electrode root and an E7018 electrode fill and cap. (Job Sheet 32)

74. Weld to specifications an open-root corner joint in the flat position with an E6010 electrode. (Job Sheet 33)

75. Weld to specifications an open-root corner joint in the horizontal position with an E6010 electrode. (Job Sheet 34)

76. Weld to specifications an open-root corner joint in the vertical position with an E6010 electrode. (Job Sheet 35)

77. Weld to specifications an open-root corner joint in the overhead position with an E6010 electrode. (Job Sheet 36)

78. Gouge a piece of mild steel with the air carbon arc cutting process. (Job Sheet 37)

Equipment, Applications, and Techniques
Unit 2

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction.

2. Review Teaching Suggestions section that follows. Plan for classroom activities.

3. Plan for enrichment of exceptional students as well as accommodation of special needs students.

4. Make transparencies from the transparency masters included with this unit. These appear in the teacher edition only and are designed to be used with the following objectives:

   TM 1—Selection Data for Mild Steel Electrodes (Objective 10)
   TM 2—Mild Steel Electrode Groups (Objective 10)
   TM 3—Electrode Sizes (Objective 10)
   TM 4—Selection Data for Stainless Steel and Other Alloy Electrodes (Objective 11)
   TM 5—Basic Motions for Electrode Manipulation (Objective 17)
   TM 6—Typical Welded Joints and Positions (Objective 21)
   TM 7—Good and Bad Welds (Objective 22)

5. Obtain films, videotapes, and other resources to supplement instruction of this unit. See ordering information in the Suggested Supplemental Resources section that follows.

6. Develop teaching plan. Adjust for different learning styles.

7. Make copies of Unit Evaluation Form.

Delivery and Application

8. Provide students with unit of instruction.

9. Discuss unit and specific objectives.

10. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.

11. Discuss the job sheets. Review criteria for evaluation of these activities.

Suggested Activities

Evaluation

12. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.

13. Make copies of the written test. Add or modify test questions as needed.

14. Give written test.

15. Compile job sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignments.

16. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in bold face type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These have been adapted by MAVCC.

1. Discuss area manufacturers who employ welders in their facilities, and the types of welding jobs that students from your program move on to. (**Personal and career development**)

2. Demonstrate all elements of the job sheets, including oxyacetylene cutting, and stress safety at all points in your demonstration.

3. Because this is an extremely long unit of instruction, break the unit into parts that will be easier to present and evaluate. The job sheets present students the challenge of mastering the welding of basic joints in all positions. These hands-on activities may be presented in groups of joints—lap, groove, corner, or T-joint, or in position groups—flat, horizontal, vertical, or overhead. In other words, because the job sheets are ordered by number, it does not mean that a student must complete them in a specific order. Choose the order that best accommodates students and makes optimal use of your welding facility.

Suggested Activities

Resources Used in Developing This Unit

1. Connor, Leonard, P., ed. *Welding Handbook Eighth Edition, Vol. 1, Welding Technology.* Miami, FL: American Welding Society, 1987.

2. O'Brien, R. L., ed. *Welding Handbook Eighth Edition, Vol. 2, Welding Processes.* Miami, FL: American Welding Society, 1991.

3. *1988/89 Welding & Fabrication Data Handbook.* Cleveland, OH: Penton Publishing, Inc., 1988.

4. *The Procedure Handbook of Arc Welding, Twelfth Edition.* Cleveland, OH: The Lincoln Electric Company, 1973.

5. *New Lessons in Arc Welding.* Cleveland, OH: The Lincoln Electric Company, 1981.

6. Fortney, Clarence, and Mike Gregory. *SMAW, Shielded Metal Arc Welding.* Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1984.

7. *Welding Power Handbook.* New York: Union Carbide Corporation, Linde Division, 1973.

8. *Carbon Arc Gouging Handbook.* New York: Union Carbide Corporation, Linde Division, 1981.

9. Koellhoffer, Leonard. *Shielded Metal Arc Welding.* New York: John Wiley & Sons, 1983.

10. Althouse, Andrew D., Carl H. Turnquist, and William A. Bowditch. *Modern Welding.* South Holland, IL: The Goodheart-Willcox Co., Inc., 1980.

Suggested Activities

Suggested Supplemental Resources

1. HOB-1, SMAW Basic; HOB-2, SMAW Advanced. Videocassette tapes, ½" VHS, and other. Available from:

   Hobart School of Welding Technology
   Trade Square East
   Troy, OH 45373
   Phone: 513-332-5217

2. HOB-637, High Speed Movie of the Welding Arc; HOB-622, Arc Welding Electrode Selection. Videocassette tapes, ½" VHS only. Available from:

   Hobart Brothers Company
   600 West Main Street
   Troy, OH 45373
   Phone: 513-332-4000

3. KEN-1, Arc Welding Fundamentals. Complete training program with videos, workbooks, teacher materials, and equipment. Available from:

   Ken Cook Education Systems
   12855 West Silver Spring Drive
   P.O. Box 207
   Butler, WI 53007
   Phone: 1-800-362-2665

4. LAW-1, Learning Arc Welding Skills. 35mm filmstrip. Available from:

   Lincoln Arc Welding Foundation
   P.O. Box 17035
   Cleveland, OH 44117-0035
   Phone: 216-481-4300

5. TEL-1, Shielded Metal Arc Welding; TEL-3, Striking Arc with E6010; TEL-4, Striking Arc with E7018; TEL-5, Stringer Beads with E6010; TEL-6, Stringer Beads with E7018; TEL-7, Weave Beads; TEL-8, Restarts of Beads; TEL-9, Weaving Tips and Techniques; TEL-10, Groove Weld, Square, Flat Position; TEL-11, Fillet Joint, Horizontal; TEL-12, Groove Weld, Horizontal, with Back. 16mm and super 8 films and videotapes. Available from:

   Tel-A-Train, Inc.
   309 North Market Street
   P.O. Box 4752
   Chattanooga, TN 37405
   Phone: 615-624-2628 or 1-800-251-6018

Suggested Activities

6. VTR-2. Shielded Metal Arc Welding. Videotapes and workbooks. Available from:

   Video Training Resource, Inc.
   7500 West 78th Street
   Edina, NM 55435-2889
   Phone: 1-800-828-8190 or 612-944-8190

   Note: The prices of materials vary depending on the length of programming and the nature of "package" materials. In most cases, educational discounts are available to recognized educational facilities. Updated catalogs of materials are available from all suppliers.

7. Guidebook Section 1, 2, 3, 4 with STOODY® information about hardfacing. Includes "The Rebuilding of Railroad Track Components by Welding," "Crushing, Grinding, Screening, and Other Quarrying and Mining Applications," and "The Rebuilding and Hardfacing of Agricultural Implements." Brochure-size printed materials. Available from:

   Stoody Delore Stellite, Inc.
   P.O. Box 1901
   16425 Gale Avenue
   Industry, CA 91749
   Phone: 818-968-0717

Equipment, Applications, and Techniques
Unit 2

Answers to Written Test

1. a. 8
   b. 4
   c. 9
   d. 2
   e. 7
   f. 3
   g. 1
   h. 5
   i. 6

2. b, c, d

3. a. Flux-covered
   b. Fuse
   c. Melted or vaporized

4. a. 3
   b. 1
   c. 2

5. a. 1
   b. 2

6. b, c, d, f

7. a. 3
   b. 4
   c. 6
   d. 1
   e. 5
   f. 2

8. a. 3
   b. 1
   c. 2
   d. 4

9. a. Copper, electrode
   b. Completed, magnetic
   c. Maximum, continued use

10. a. Electric arc welding electrode
    b. Minimum
    c. Position
    d. Mild steel
    e. Alloy
    f. Diameter expressed in fractions of an inch

11. a. O
    b. S

Answers to Written Test

12. a. Of the base metal
b. Largest, highest
c. $\frac{5}{32}''$
d. The first pass
e. With most codes
f. Large electrodes
g. Up, down
h. Long, short
i. DC

13. a. W
b. T

14. a. S
b. T

15. a. Less
b. Hissing, crackling
c. Penetration
d. Be difficult to remove
e. Too little

16. a. 3
b. 1
c. 2

17. a. 4
b. 8
c. 6
d. 1
e. 9
f. 2
g. 5
h. 3
i. 7

18. a, b, d, e, g

19. a. 1. Slowly up and slightly backward
2. Slow, backward
b. 1. Sideways
2. Remove slag from
3. Back toward
4. 60° in the direction of travel
5. Backward

20. a. 3
b. 2
c. 1

Answers to Written Test

21. a. B
    b. G

22. a. 4
    b. 1
    c. 6
    d. 3
    e. 7
    f. 5
    g. 2

23. a. 1
    b. 3
    c. 2

24. a. 3
    b. 3
    c. 2

25. a. 2
    b. 3
    c. 3

26. a. 2
    b. 1

27. a. 2
    b. 3
    c. 1

28. a. 2
    b. 1
    c. 3

29. a. 2
    b. 2

30. a, b

31. a, b

32. a. 3
    b. 1
    c. 2

33. a. 2
    b. 4
    c. 3
    d. 1

Answers to Written Test

34. a. 2
    b. 1
    c. 3

35. a. Electrode size
    b. Shallow
    c. V
    d. Depth

36. a. An irregular surface and edge
    b. Slag-free

37. a. Deeper
    b. Decreases, increases, decreases
    c. Depth

38. a. 3
    b. 1
    c. 2

39. a. Edges and surfaces
    b. Farm equipment
    c. Metal to metal impact

40. b, c, d

41. a. Chemical, a drying oven
    b. Drying oven manufacturer

Equipment, Applications, and Techniques
Unit 2

Written Test

Name ______________________________ Score ______________

1. Match the terms on the right with their correct definitions.

______a. A line through the length of a weld, perpendicular to the cross-section at its center of gravity

______b. The weight of material deposited in a unit of time

______c. The final bead or beads needed to complete a welded joint

______d. The remainder of the beads required to complete the joint from the root bead out to the cap pass

______e. A weld bead that extends into or includes parts or all of the joint root

______f. Any procedure or device for protecting an in-process weld from atmospheric contamination

______g. A nonmetallic product resulting from the mutual dissolution of flux and nonmetallic impurities in some welding and brazing processes

______h. A type of weld bead made without appreciable weaving motion

______i. Hydrogen, oxygen, and nitrogen in air

1. Slag
2. Filler pass
3. Shielding
4. Deposition rate
5. Stringer bead
6. Air contaminants
7. Root bead
8. Axis of a weld
9. Cap pass

2. Select true statements about advantages of SMAW. Place an "X" beside each true statement.

______a. Equipment is relatively expensive.

______b. Equipment is portable because the welding machines can be powered with gasoline or diesel powered engines.

Written Test

_______c. Applications are relatively simple and can be adapted to many job requirements.

_______d. SMAW is well suited for maintenance and repair work in small shops, on farms, and in garages.

3. Complete statements about the principles of SMAW. Circle the information that best completes each statement.

   a. An electric arc is struck between a grounded base metal and a (flux-covered) (base) electrode held in a holder and manipulated by hand.

   b. The heat of the arc melts the base metal and the metal in the electrode so that the two (fuse) (stick) together to create the weld.

   c. Flux contained on the electrode covering is also (fused or vented) (melted or vaporized) to provide shielding that protects the weld from contaminants in the air, hence the name shielded metal arc welding.

4. Solve problems about the relationship of arc, base metal, electrode, and flux. Select the best answer to each of the following scenarios.

   a. A fellow student is trying to define what happens when an electrode is held about ⅛" away from the base metal. The phrase he is looking for is:

      (1) Electrode activation
      (2) Spark
      (3) Arc stream

   b. Another fellow student is trying to explain what happens to the molten pool or crater in the welding process. The student says that it hardens, but more accurately:

      (1) The crater tends to move away from the arc and cool and solidify.
      (2) The crater stays right beneath the arc to afford pinpoint welding accuracy.
      (3) The crater cools as the arc moves along.

   c. Your instructor asks you to identify the covering that forms over a weld because of flux from the covered electrode. The covering is called:

      (1) Kerf
      (2) Slag
      (3) Contaminant

Written Test

5. Differentiate between elements of flux-covered electrode functions. Select the best answer to the following conditions.

   a. The part of the electrode that melts in the arc stream to provide filler metal is:

      (1) The core of metal wire
      (2) The baked-on chemical covering
      (3) The flux

   b. Another part of the electrode that melts in the arc stream helps to stabilize the arc and provide a shield around the arc. but it also:

      (1) Assures 100 percent deposition
      (2) Provides a slag covering to protect the weld
      (3) Helps the weld cool faster

6. Select true statements about benefits of learning SMAW. Place an "X" beside each true statement.

   _______a. SMAW introduces a beginner to the basics of all welding processes.

   _______b. SMAW acquaints the beginner with the welding machines and electrical accessories used in other arc welding processes.

   _______c. SMAW introduces the beginner to the world of electrodes and their relationship to metal thicknesses. welding speeds. and amperage requirements.

   _______d. SMAW acquaints the beginner with the basic concepts of shielding and how shielding improves and protects a weld.

   _______e. SMAW helps the student develop the mental attitudes required to work with other arc welding processes.

   _______f. SMAW gives the beginner an added welding skill that will add versatility to job-getting resumes.

Written Test

7. Match welding machines with their electrical characteristics. Place the numbered characteristic beside the appropriate definition.

______a. Current must travel in a complete loop from the power supply to the arc and back to the power supply, and the circuit must be grounded.

______b. This is the direction that current flows through a basic welding circuit, and is expressed as positive or negative in relation to DC current.

______c. This is current that alternates from one direction to another 60 times per second, and is expressed as 60 Hertz.

______d. This is current that flows in only one direction.

______e. This is produced by a negative electrode and a positive workpiece that causes the current to flow from the electrode to the workpiece.

______f. This is produced by a positive electrode and a negative workpiece that causes the current to flow from the workpiece to the electrode.

1. DC
2. DCEP
3. Basic circuit
4. Polarity
5. DCEN
6. AC

8. Match welding machine performance characteristics with their applications. Place the numbered characteristic beside the appropriate definition.

______a. These machines change high-voltage, low-amperage AC to low-voltage, high-amperage AC in machines that usually have a 220/240 volt input current.

______b. These machines change high-voltage, low-amperage AC to low-voltage, high-amperage AC or DC, and these machines are ideal for adjustment to different materials and welding positions.

1. AC or DC transformer-rectifier
2. DC generator
3. AC transformer
4. Duty cycle

______c. In these machines, current varies with the speed the armature turns, polarity changes may be made by flipping a switch or reversing weld connections, and some of these machines are powered with AC motors while others are powered with gas or diesel engines.

______d. Sizes of welding machines are rated in accordance with their amperage capacity at 60 percent duty cycle.

9. Complete statements about basic SMAW accessories and their purposes. Circle the information that best completes each statement.

   a. Cables are insulated (copper) (aluminum), extra-flexible leads that carry the current from the power source to the (rest of the system) (electrode), and they vary in size or diameter according to machine capacity and length requirements.

   b. Clamps are used to fasten the cables to a workpiece or table where the workpiece is positioned so that the welding circuit will be (DCEP) (completed), and some operate with spring pressure while others are (welded on) (magnetic).

   c. Electrode holders are hand-held clamping devices that hold the electrode during the welding process; they should be selected according to the machine's (maximum) (minimum) output rating, and they should be well insulated, lightweight to keep a welder from tiring, and sturdy enough to stand up under (exposure to rain) (continued use).

10. Complete statements about AWS electrode classifications for mild steel and low alloy electrodes. Circle the information the best completes each statement.

   a. The prefix "E" designates an (electrode) (electric arc welding electrode).

   b. The first two digits of 4-digit numbers and the first three digits of 5-digit numbers indicate (minimum) (maximum) tensile strength.

   c. The next-to-last digit indicates (type of weld it is suitable for) (position).

   d. The last digit (0 through 8) together with the next-to-last digit indicate the type of covering and current to be used, and (high-carbon steel) (mild steel) electrodes are also classified as fast-freeze, fill-freeze, fast-fill, and low hydrogen.

   e. The last letter and digit indicate the approximate (amount of copper) (alloy) in the deposit.

Written Test

f. In addition to the AWS classification system, electrodes are also classified according to (length and diameter expressed in feet and inches) (diameter expressed in fractions of an inch).

11. Differentiate between stainless steel and other alloy electrodes. Place an "S" beside the definition of stainless steel electrodes and an "O" beside the definition of other alloy electrodes.

______a. These have chemical symbols which precede the digits.

______b. These are numbered to match specific types of metals.

12. Complete statements about basic elements of arc welding and their importance. Circle the information that best completes each statement.

a. Electrode selection must be related to both the type and thickness of a base metal, and one rule of thumb is that electrode diameter should not exceed the thickness (of the base metal) (of the base metal by more than ⅛").

b. Welding speed is the greatest factor in reducing welding costs, and one rule of thumb is to use the (largest) (smallest) allowable electrode at the (highest) (lowest) acceptable amperage.

c. In welding positions for vertical, overhead, and horizontal butt welds, the maximum size for an E6010 or E6011 is $\frac{3}{16}$", and for these same positions with a low-hydrogen electrode, the maximum size is ($\frac{5}{32}$") (also $\frac{3}{16}$").

d. For joint preparation a narrow V-groove in a butt joint will usually prevent the use of a large electrode on (the first pass) (finish passes).

e. With fit-up, backup strips are permitted (with most codes) (anytime).

f. Machine capacity is important because amperage ratings on some welding machines may not be large enough to properly handle (low hydrogen) (large electrodes).

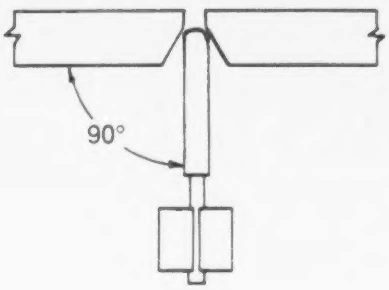
g. Amp settings are always determined by electrode selection and welding position, and the rule of thumb is to turn your amps down when welding vertical (up) (down) and to turn your amps up when welding vertical (down) (up).

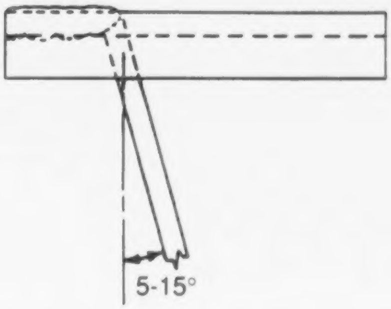
h. The rule of thumb for voltage changes between the electrode and the base metal is that a (long) (short) arc increases voltage and a (short) (long) arc decreases voltage.

i. Polarity is determined by electrode selection, and correct polarity is extremely important in (DC) (AC) electric arc welding processes.

Written Test

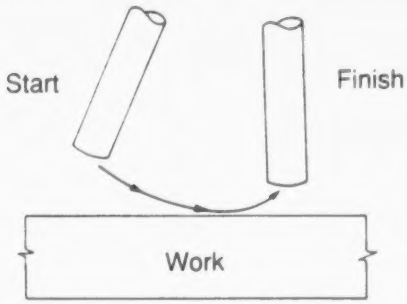
13. Differentiate between electrode angles. Place a "T" below the illustration of a travel angle, and a "W" below the illustration of a work angle.

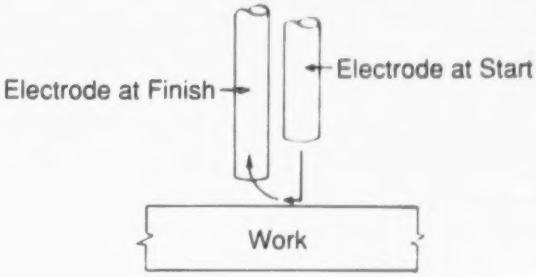




a. ______________________ b. ______________________

14. Differentiate between SMAW starting techniques. Place an "S" below the illustration of the scratch method and a "T" below the illustration of the tap method.





a. ______________________ b. ______________________

15. Complete statements about techniques for controlling arc gap. Circle the information that best completes each statement.

   a. Arc gap should usually be slightly (more) (less) than the diameter of the electrode.

   b. Too much gap can usually be identified by a (crackling) (hissing) sound as opposed to a (crackling) (hissing) sound.

   c. Too much gap can be spotted visually because it causes excess spatter and poor (adhesion) (penetration).

   d. Too much gap will cause filler metal to melt off in large wobbly drops, and slag will (not form properly) (be difficult to remove)

Written Test

e. With (too little) (too much) gap, the arc will not start, or the electrode may freeze to the weld puddle and stick there.

16. Complete statements about techniques for using electrode angles. Circle the best answer for each of the following situations.

    a. The electrode work angle refers to the electrode's angular relationship to:

        (1) The direction of travel
        (2) The worktable
        (3) The base metal

    b. The electrode travel angle refers to the electrode's angular relationship to:

        (1) The direction in which welding moves
        (2) The movements a welder uses to maintain position
        (3) The distance of a weld

    c. A rule of thumb for maintaining a proper work angle is to keep the electrode:

        (1) At a 45° angle from the base metal
        (2) At a 90° angle from the base metal
        (3) At any angle that is comfortable

17. Match bead running techniques with their procedures. Place the numbered technique name beside its proper definition.

______a. Used with high-deposit, fast-fill electrodes and consists of lightly dragging the electrode tip along the base metal to force the molten filler metal uniformly out from under the electrode tip which in turn provides good penetration

______b. Can be used with fast-freeze electrodes to make the first pass on vertical fillet and V-groove butt welds

1. Side-to-side weave
2. Box weave
3. Stringer bead
4. Drag
5. Circular motion
6. Whipping

Written Test

______c. Used with fast-freeze electrodes to make stringer beads in all positions and on all types of joints, and consists of maintaining a short arc when in the crater and a long arc as the electrode is drawn out of the crater so the molten pool will stay small and allow the filler metal to freeze quickly so the metal does not spill through the joint

______d. Used with all types of electrodes to make fill passes on vertical fillet and V-groove butt welds, and also sometimes used with fill-freeze and low-hydrogen electrodes to make the first pass on these joints

______e. Used with fill-freeze and low-hydrogen electrodes to make the first pass on vertical fillet and V-groove butt welds because it provides a larger weld than a side-to-side weave

______f. Used with all types of electrodes to make the fill pass on vertical fillet and V-groove butt welds, and is similar to the side-to-side weave, but with a distinct pause and slight upward motion at each edge of the weld to assure complete crater fill-up and eliminate undercutting

______g. Used with all types of electrodes to make overhead welds

______h. A single, straight line bead used with certain types of electrodes, and consists of a drag or whipping motion used in all welding positions

______i. Used with all types of electrodes to build up metal surfaces with one or more layers of weld beads, and can be used on either flat or curved surfaces as overlapping straight beads or overlapping weave beads

7. Padding

8. Whipping with slight weave in crater

9. Triangular weave

Written Test

18. Select true statements about the technique for stopping and restarting an arc. Place an "X" beside each true statement.

______a. Anticipate the point where the rod is going to be used up or where welding will stop.

______b. Stop the forward motion of the electrode.

______c. Quickly withdraw the electrode to break the arc.

______d. Chip the slag off the end of the weld about ¼″ to ½″ back.

______e. Restart the arc about ½″ in front of the forward end of the crater.

______f. Move the electrode slowly back to the back crown of the crater and immediately resume welding in the direction of travel.

______g. If the stop/restart procedure is properly executed, any marks left by restarting the arc ahead of the crater will be covered as the weld bead is continued.

19. Complete statements about techniques for filling a crater at the end of a weld. Circle the information that best completes each statement.

a. Option 1:

(1) Just before the bead reaches the end of the plate, draw the electrode (slowly up and slightly backward) (quickly up and slightly forward) over the completed weld.

(2) Make sure the motion is (slow) (fast) enough to allow the crater to fill and that the (backward) (forward) motion is far enough that the crater remains on top of the bead about ¼″ to ½″ back from the end of the weld.

b. Option 2:

(1) Break the arc about 1″ to 2″ from the end of the weld by quickly shortening the arc and pulling it (sideways) (straight up) out of the crater.

(2) Chip and (grind) (remove slag from) the end of the bead.

(3) Move to the end of the plate, restart the arc, and weld (back toward) (over) the bead.

Written Test

(4) Incline the electrode about (90° from the base metal) (60° in the direction of travel).

(5) Weld back over the crater and stop the arc by pulling up and slightly (forward) (backward) as the two beads run together and the crater forms properly on top of the bead.

20. Select guidelines for using feathered edges for tie-ins. Circle the best answer for each of the following:

a. A tie-in point should always be chipped and brushed:

(1) Only from a tack weld
(2) Only when restarting a bead
(3) When restarting a bead or when starting from a tack weld

b. Another case where a feathered edge should be used is:

(1) Anytime a bead is restarted
(2) When a weld deposit is too large to make a normal tie-in
(3) To end a weld properly

c. Feathering requires a sloping, sharp edge at the end of a bead, and this is accomplished with:

(1) A hand grinder
(2) A file
(3) A chipping hammer

21. Differentiate between basic steps in joint preparation. Place a "B" beside the definition for beveling and a "G" beside the definition for grinding.

______a. This requires putting angles on pieces of material so that when they are joined, the weld will get good penetration below the surface of the base metal.

______b. This requires the use of an abrasive device, usually portable, to remove metal or slag from the weld area.

Written Test

22. Match good and bad welds with their characteristics. Place the numbered weld condition beside the appropriate characteristic.

_______a. Smooth well-formed bead with no undercutting, overlapping, or piling of slag

_______b. Poor penetration, slow progress, excessive piling of weld metal, and slag inclusion

_______c. Excessive spatter and undercutting of weld joints

_______d. Poor penetration with flat bead, weld zone not shielded

_______e. Poor penetration and humped bead

_______f. Excessive heat and weld metal reinforcement leading to unnecessary distortion of joint

_______g. Irregular bead, poor penetration, undercut, and not enough weld metal in joint, causing a weak joint

1. Current low
2. Speed fast
3. Voltage high
4. Current, voltage, and speed normal
5. Speed slow
6. Current high
7. Voltage low

23. Select causes of and remedies for arc blow. Circle the information that best completes each statement.

a. Arc blow is caused by:

(1) Magnetic forces present in DC
(2) Contaminants in the air
(3) Out of position welding

b. Arc blow can also cause:

(1) The electrode to freeze to the puddle
(2) Poor tie-ins
(3) The arc to blow wildly and spatter badly

c. One remedy for controlling arc blow is to reduce current or switch polarity, but other remedies include:

(1) Changing welding cables and holder
(2) Changing current to AC, changing ground clamp location, and maintaining a short arc
(3) Increasing amperage and speed

Written Test

24. Select causes of and remedies for pinholes and porosity. Circle the information that best completes each statement.

    a. Both pinholes and porosity can be caused when:

        (1) Arc length is too short
        (2) Travel speed is too slow
        (3) Arc length is too long and travel speed is too fast

    b. Pinholes and porosity can also be caused by faulty electrodes, incorrect polarity, or:

        (1) Bad joint design
        (2) Bad flux
        (3) Surface conditions of the base metal

    c. Remedies for pinholes and porosity include:

        (1) Increasing welding speed and turning up amperage
        (2) Using a shorter arc length and keeping the puddle molten for a longer period
        (3) Switching polarity and changing to a small electrode

25. Select causes of and remedies for undercutting. Circle the information that best completes each statement.

    a. Undercutting is usually caused when:

        (1) Surface metals are not properly prepared
        (2) Arc length is too long or current is too high
        (3) Polarity is wrong

    b. Undercutting can also be caused by:

        (1) Too large an electrode
        (2) A welding speed that is too slow
        (3) Improper manipulation of rod angle or a welding speed that is too fast

    c. The most common remedies for undercutting would be to:

        (1) Try a larger electrode or faster travel speed
        (2) Lengthen the arc length and increase current
        (3) Reduce the current and shorten the arc length

Written Test

26. Select causes of and remedies for weld spatter. Circle the information that best completes each statement.

    a. Weld spatter is caused by:

        (1) Bad electrode angle
        (2) Too much current and too long an arc length
        (3) Too small electrode

    b. Weld spatter can be remedied by:

        (1) Reducing current and shortening arc length
        (2) Using a larger electrode
        (3) Changing electrode work angle

27. Select causes of and remedies for incomplete penetration. Circle the information that best completes each statement.

    a. Incomplete penetration can be caused by insufficient welding current, too large an electrode, or too fast a welding speed, but another cause could be:

        (1) Surface conditions of base metal
        (2) Faulty joint design
        (3) Bad electrode travel angle

    b. One remedy for incomplete penetration is to:

        (1) Decrease welding current
        (2) Increase welding speed
        (3) Check the joint carefully

    c. Other remedies for incomplete penetration include:

        (1) Increasing weld current, reducing welding speed, and using a smaller diameter electrode
        (2) Reducing weld current, increasing welding speed, and using a larger diameter electrode
        (3) Moving the ground to a new location on the workpiece and increasing weld current

Written Test

28. Select causes of and remedies for slag inclusion. Circle the information that best completes each statement.

    a. Slag inclusion can be caused by:

        (1) Improper bevel angle
        (2) Sharp, V-shaped recess in the joint design
        (3) Too high a welding current

    b. Slag inclusion may also result from:

        (1) High flow rate of molten metal or a weld current too low
        (2) Too small a diameter electrode
        (3) Wrong polarity

    c. One remedy for slag inclusion is to use a higher welding current, but eradicating slag inclusion sometimes requires:

        (1) Redesigning the joint
        (2) Grinding
        (3) Preheating and increasing the size of the weld area

29. Select causes of and remedies for excessive weld reinforcement. Circle the information that best completes each statement.

    a. Weld reinforcement can be caused by poor electrode movement, but it is usually caused by:

        (1) Arc blow
        (2) The wrong electrode size or too slow a travel speed
        (3) Out of position welding

    b. Aside from maintaining good electrode movement, the remedies for excessive weld reinforcement include:

        (1) Increasing amperage and slowing travel speed
        (2) Choosing the correct electrode and increasing travel speed
        (3) Reversing polarity and choosing a larger electrode

Written Test

30. Select true statements about the principles of air carbon arc cutting. Place an "X" beside each true statement.

______a. CAC-A is a cutting process that cuts or gouges metal by using an electric arc between a carbon electrode and a base metal.

______b. As the arc melts the base metal, a controlled stream of compressed air is directed at the arc to remove molten metal to make a complete cut or produce a groove.

______c. CAC-A is popular because the equipment required is only a standard welding machine.

31. Select true statements about CAC-A power sources. Place an "X" beside each statement that is true.

______a. Standard power sources for arc welding can be used for CAC-A, but an opening circuit voltage of at least 60 volts is required.

______b. Air pressure required to make a cut depends on the diameter of the carbon electrode, and air pressures usually range from a minimum of 40 psi to 80 psi and above.

32. Match types of CAC-A electrodes with their characteristics. Place the number of the electrode type beside the correct definition.

______a. Made of graphite (carbon) for DC operation in sizes from $\frac{5}{32}$″ to 1″

______b. Used for cutting or gouging high-purity copper or cast iron and available with a $\frac{1}{4}$″ diameter and 18″ long

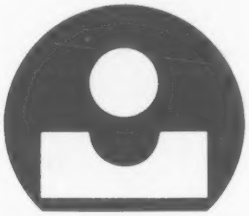
______c. Electrode has no copper coating, which tends to make the electrode "pencil" or cause a gradual decrease in the size of a groove

1. Flux-coated steel
2. Graphite
3. Copper-coated

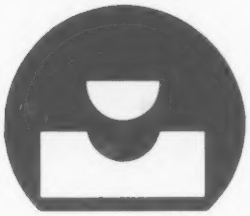
Written Test

33. Match CAC-A electrode shapes with their uses. Place the numbered electrode type beside the correct illustration.

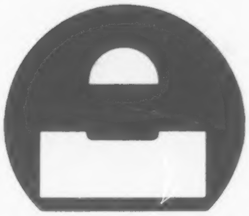
1. Used to make a flat groove
2. Used to gouge a U groove
3. Can be turned to gouge a flat groove
4. Can be used to gouge a U groove



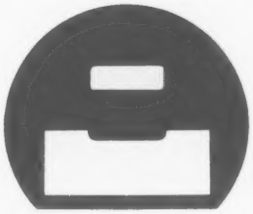
_______a.



_______b.



_______c.



_______d.

Written Test

34. Match CAC-A electrode angles with their uses. Place the numbered angle beside the correct definition.

______a. The preferred angle for gouging

______b. A nonpreferred angle that is higher and causes the groove to cut deeper into the base metal and impair metal removal

______c. A nonpreferred angle that is lower and causes the groove not to cut as deeply into the base metal

1. More than 45° between electrode and work

2. 35° to 45° between electrode and work

3. Less than 35° between electrode and work

35. Complete statements about amperage selection for gouging. Circle the information that best completes each statement.

a. Amperage should be selected according to power source and (job at hand) (electrode size).

b. When amperage is lower than recommended, the groove will retain a U shape, but it will be (shallow) (rough).

c. When the amperage is higher than recommended, approximately 15 percent higher, the groove will change from a U to a (W) (V) shape.

d. When amperage is set as recommended, the groove will have a uniform U shape with good (depth) (surface).

36. Complete statements about air pressure and how it affects gouging. Circle the information that best completes each statement.

a. Low air pressure tends to produce (an irregular surface and edge) (a shallow groove).

b. Correct air pressure allows for (deep) (slag-free) cuts.

37. Complete statements about travel speed and how it affects gouging. Circle the information that best completes each statement.

a. Slow travel speed generates more heat input into the base metal and produces a (wider) (deeper) groove.

b. High travel speed (increases) (decreases) metal removal, and as travel speed (increases) (decreases), metal removal (increases) (decreases) accordingly.

c. Correct travel speed produces a groove (width) (depth) that is approximately half the diameter of the electrode.

Written Test

38. Match techniques for gouging with their procedures. Place the numbered technique beside the correct definition.

_______a. Should be done in the down direction to allow for safe removal of molten metal

_______b. May be done left or right, but airstream must remain behind the electrode with respect to the direction of travel

_______c. Requires that the electrode be perpendicular to the base metal and angled so that molten metal will not drop on the operator

1. Horizontal gouging
2. Overhead gouging
3. Vertical gouging

39. Complete statements about hardfacing. Circle the information that best completes each statement.

a. Hardfacing is a form of surfacing designed to increase the service life of machine parts whose (edges and surfaces) (wheels and cams) are subject to excessive wear from abrasion, impact, or corrosion.

b. Hardfacing can effectively restore parts subject to metal to ground wear—parts such as dozer blades and tillage parts on (farm equipment) (crushing machines).

c. Hardfacing can also restore parts subject to metal to metal wear—parts such as wheels on cranes and mine cars which are subject to continuous or repeated (metal to metal impact) (operation).

40. Select true statements about elements affecting hardfacing. Place an "X" beside each true statement.

_______a. Hardfacing a worn part is usually more expensive than buying a new part, and the cost factor of hardfacing should always be considered.

_______b. It is important to know what kind of wear a part is subjected to so that hardfacing electrodes can be properly selected.

_______c. Knowing the base metal from which the part is made is vital to planning the hardfacing process required.

_______d. The size of the part and number of surfaces that require hardfacing affect the cost of hardfacing.

Written Test

41. Complete statements about electrode drying ovens. Circle the information that best completes each statement.

    a. Because moisture can change the (electrical) (chemical) composition of some flux-covered electrodes, certain electrodes need to be stored in drying ovens and sometimes reconditioned or rebaked in (a drying oven) (an industrial kiln).

    b. Reconditioning or rebaking times should be as recommended by the (drying oven manufacturer) (electrode manufacturer) in relation to electrode type and relative humidity of the storage area.

*Permission to duplicate this test is granted.

Equipment, Applications, and Techniques
Unit 2

Unit Evaluation Form

Student Name ______________________________ Unit Rating __________

Job Sheet 1—Start and Restart an Arc, Crater, and Backfill at the Edge While Running a Bead on Mild Steel Plate Rating _____

Comments: ____

____

Job Sheet 2—Build a Pad on Mild Steel Plate in the Flat Position with an E6010 Electrode Rating _____

Comments: ____

____

Job Sheet 3—Build a Pad on Mild Steel Plate in the Flat Position with an E7018 Electrode Rating _____

Comments: ____

____

Job Sheet 4—Weld to Specifications a Fillet Weld Lap Joint in the Flat Position with an E6010 Electrode Rating _____

Comments: ____

____

Job Sheet 5—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Flat Position with an E6010 Electrode Rating _____

Comments: ____

____

Job Sheet 6—Weld to Specifications a Fillet Weld Lap Joint in the Flat Position with an E7018 Electrode Rating _____

Comments: ____

____

Unit Evaluation Form

Job Sheet 7—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Flat Position with an E7018 Electrode Rating ______

Comments: ______________________________

____

Job Sheet 8—Weld to Specifications a Fillet Weld Lap Joint in the Flat Position with an E7024 Electrode Rating ______

Comments: ______________________________

____

Job Sheet 9—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Flat Position with an E7024 Electrode Rating ______

Comments: ______________________________

____

Job Sheet 10—Weld to Specifications a Fillet Weld Lap Joint in the Horizontal Position with an E6010 Electrode Rating ______

Comments: ______________________________

____

Job Sheet 11—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Horizontal Position with an E6010 Electrode Rating ______

Comments: ______________________________

____

Job Sheet 12—Weld to Specifications a Fillet Weld Lap Joint in the Horizontal Position with an E7018 Electrode Rating ______

Comments: ______________________________

____

Job Sheet 13—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Horizontal Position with an E7018 Electrode Rating ______

Comments: ______________________________

____

Unit Evaluation Form

Job Sheet 14—Weld to Specifications a Fillet Weld Lap Joint in the Horizontal Position with an E7024 Electrode Rating ______

Comments: ______________________________

____

Job Sheet 15—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Horizontal Position with an E7024 Electrode Rating ______

Comments: ______________________________

____

Job Sheet 16—Weld to Specifications a Fillet Weld Lap Joint in the Verticle Position with an E6010 Electrode Rating ______

Comments: ______________________________

____

Job Sheet 17—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Vertical Position with an E6010 Electrode Rating ______

Comments: ______________________________

____

Job Sheet 18—Weld to Specifications a Fillet Weld Lap Joint in the Vertical Position with an E7018 Electrode Rating ______

Comments: ______________________________

____

Job Sheet 19—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Vertical Position with an E7018 Electrode Rating ______

Comments: ______________________________

____

Job Sheet 20—Weld to Specifications a Fillet Weld Lap Joint in the Overhead Position with an E6010 Electrode Rating ______

Comments: ______________________________

____

Unit Evaluation Form

Job Sheet 21—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Overhead Position with an E6010 Electrode Rating ______

Comments: ______________________________

____

Job Sheet 22—Weld to Specifications a Fillet Weld Lap Joint in the Overhead Position with an E7018 Electrode Rating ______

Comments: ______________________________

____

Job Sheet 23—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Overhead Position with an E7018 Electrode Rating ______

Comments: ______________________________

____

Job Sheet 24—Weld to Specifications a V-Groove Butt Joint in the Flat Position with an E6010 Electrode Rating ______

Comments: ______________________________

____

Job Sheet 25—Bend Test a Welded V-Groove Joint Rating ______

Comments: ______________________________

____

Job Sheet 26—Weld to Specifications a V-Groove Butt Joint in the Horizontal Position with an E6010 Electrode Rating ______

Comments: ______________________________

____

Job Sheet 27—Weld to Specifications a V-Groove Butt Joint in the Vertical Position with an E6010 Electrode Rating ______

Comments: ______________________________

____

Unit Evaluation Form

Job Sheet 28—Weld to Specifications a V-Groove Butt Joint in the Overhead Position with an E6010 Electrode Rating ______

Comments: ____

____

Job Sheet 29—Weld to Specifications a V-Groove Butt Joint in the Flat Position with an E6010 Electrode Root and an E7018 Electrode Fill and Cap Rating ______

Comments: ____

____

Job Sheet 30—Weld to Specifications a V-Groove Butt Joint in the Horizontal Position with an E6010 Electrode Root and an E7018 Electrode Fill and Cap Rating ______

Comments: ____

____

Job Sheet 31—Weld to Specifications a V-Groove Butt Joint in the Vertical Position with an E6010 Electrode Root and an E7018 Electrode Fill and Cap Rating ______

Comments: ____

____

Job Sheet 32—Weld to Specifications a V-Groove Butt Joint in the Overhead Position with an E6010 Electrode Root and an E7018 Electrode Fill and Cap Rating ______

Comments: ____

____

Job Sheet 33—Weld to Specifications an Open-Root Corner Joint in the Flat Position with an E6010 Electrode Rating ______

Comments: ____

____

Job Sheet 34—Weld to Specifications an Open-Root Corner Joint in the Horizontal Position with an E6010 Electrode Rating ______

Comments: ____

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Unit Evaluation Form

Job Sheet 35—Weld to Specifications an Open-Root Corner Joint in the Vertical Position with an E6010 Electrode Rating ______

Comments: ____________________

____

Job Sheet 36—Weld to Specifications an Open-Root Corner Joint in the Overhead Position with an E6010 Electrode Rating ______

Comments: ____________________

____

Job Sheet 37—Gouge a Piece of Mild Steel with the Air Carbon Arc Cutting Process Rating ______

Comments: ____________________

____

Written Test Scores

Pretest ______ Posttest ______ Other ______

Other ____________________

____

Teacher Signature ____________________ Date ________

Student Signature ____________________ Date ________

***Permission to duplicate this form is granted.**

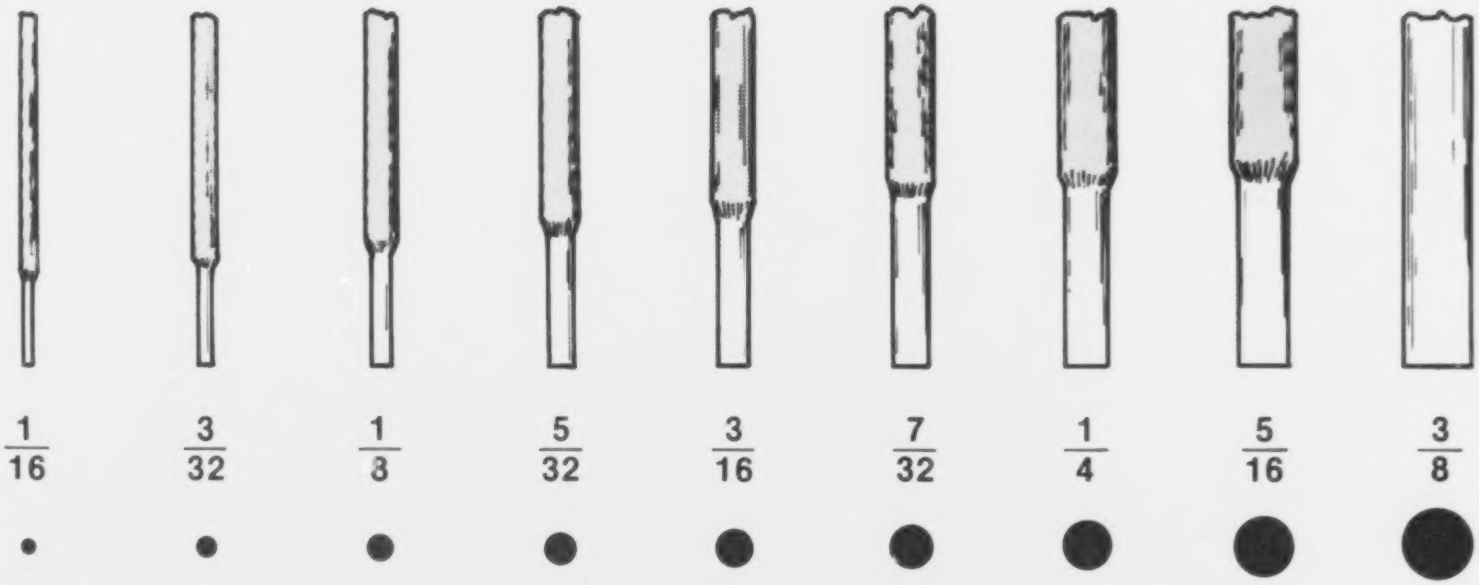
Selection Data for Mild Steel Electrodes

	ELECTRODE POLARITY	SIZES AND CURRENT RANGES (Amps.)							
AWS CLASS	(+) = POSITIVE (-) = NEGATIVE	5/64" SIZE	3/32" SIZE	1/8" SIZE	5/32" SIZE	3/16" SIZE	7/32" SIZE	1/4" SIZE	5/16" SIZE
					MILD STEEL				
E6010	DC(+)		40-75	75-130	90-175	140-225	200-275	220-325	240-400
E6012	DC(−)			80-135	110-180	155-250	225-295	245-325	
	AC			90-150	120-200	170-275	250-325	275-360	
E6011	AC		50-85	75-120	90-160	120-200	150-260	190-300	
	DC(+)		40-75	70-110	80-145	110-180	135-235	170-270	
E6011	AC			80-130	120-160				
	DC(±)			70-120	110-150				
E6013	AC	50-80	75-105	110-150	160-200	205-260			
	DC(±)	45-75	70-95	100-135	145-180	190-235			
E7014	AC			110-160	150-225	200-260	260-340	280-425	
	DC(−)			100-145	135-200	180-235	235-305	260-380	
E6013	AC			100-150	150-200	200-260			
	DC(±)			90-135	135-180	180-235			
E6011	AC		40-90	60-120	115-150				
	DC(+)		40-80	55-110	105-135				
E7024	AC		65-102	115-175	180-240	240-300	300-380	340-440	
	DC(±)		60-110	100-160	160-215	220-280	270-340	320-400	
E6027	AC				190-240	250-300	300-380	350-450	
	DC(±)				175-215	230-270	270-340	315-405	
E7024	AC			115-175	180-240	240-315	300-380	350-450	380-600
	DC(±)			100-160	160-215	215-285	270-340	315-405	360-600
E7018	DC(+)		70-100	90-150	120-190	170-280	210-330	290-430	375-500
	AC		80-120	110-170	135-225	200-300	260-380	325-440	400-530
E7018-1	DC(+)		70-110	95-160	120-190	180-270	250-330	300-400	
	AC		80-110	100-170	135-225	210-290	270-370	325-420	
7018 (white numbers)	DC(+)		85-110	110-160	130-200	180-270	250-330	300-400	
	AC			120-170	140-230	210-290	270-370	325-420	
E7028	AC				180-270	240-330	275-410	360-520	
	DC(+)				170-240	210-300	260-380		

Mild Steel Electrode Groups

AWS #	Group	Characteristics	Applications
E6010 E6011	Fast-Freeze	Produce a deep, penetrating arc that leaves a fast-freezing flat bead with little slag	All types of welding in all positions, and almost always used with reverse polarity although some can be used with AC
E6012 E6013 E7014	Fill-Freeze	Produce a moderate arc and leaves beads with distinct, even ripples with complete slag coverage	Can be used in all positions, but preferred for overhead and vertical welding, and are commonly straight polarity electrodes although sometimes used with AC
E6027 E7024	Fast-Fill	Heavily coated with iron powder to produce a soft arc that provides a fast deposit rate and leaves a smooth bead with heavy slag	Frequently used in production welding where work can be positioned for downhand welding
E7018	Low Hydrogen	Little hydrogen in coating, but must be used soon after opening or stored in a drying oven to avoid moisture	Can be used in all positions, and are first choice for welding problem steels because off outstanding crack-resistance and elimination of porosity

Electrode Sizes
(Actual Sizes)


1/16
3/32
1/8
5/32
3/16
7/32
1/4
5/16
3/8

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TM 3

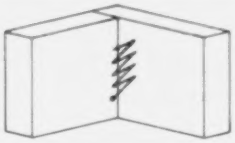
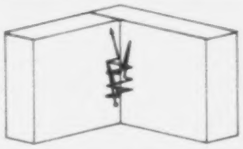
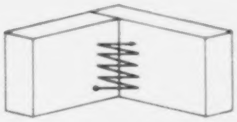
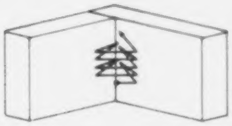
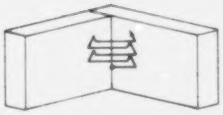
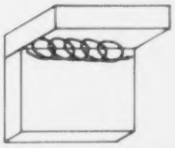
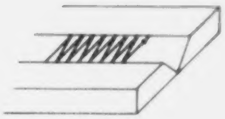
Selection Data for Stainless Steel and Other Alloy Electrodes

AWS CLASS	ELECTRODE POLARITY (+) = POSITIVE (−) = NEGATIVE	SIZES AND CURRENT RANGES (Amps.) 5/64" SIZE	3/32" SIZE	1/8" SIZE	5/32" SIZE	3/16" SIZE	7/32" SIZE	1/4" SIZE	5/16" SIZE
STAINLESS STEEL									
E308-15	DC(+)		30-70	50-100	75-130	95-165		150-225	
E308-16	DC(+); AC	20-45	30-60	55-95	80-135	115-185		200-275	
E308L-16	DC(+); AC		30-65	55-100	80-140	115-190			
E309-16	DC(+); AC		30-60	55-95	80-135	115-185		200-275	
E310-15	DC(+)		30-70	45-95	80-135	100-165			
E310-16	DC(+); AC		30-65	55-100	80-140	120-185		200-275	
E316L-16	DC(+), AC		30-65	55-100	80-140	115-190			
E347-15	DC(+)		30-70	50-100	75-130	95-165			
E347-16	DC(+), AC		30-60	55-95	80-135	115-185			
BRONZE AND ALUMINUM									
E-CuSn-C	DC(+)			50-125	70-170	90-220			
Al-43	DC(+)		20-55	45-125	60-170	85-235			

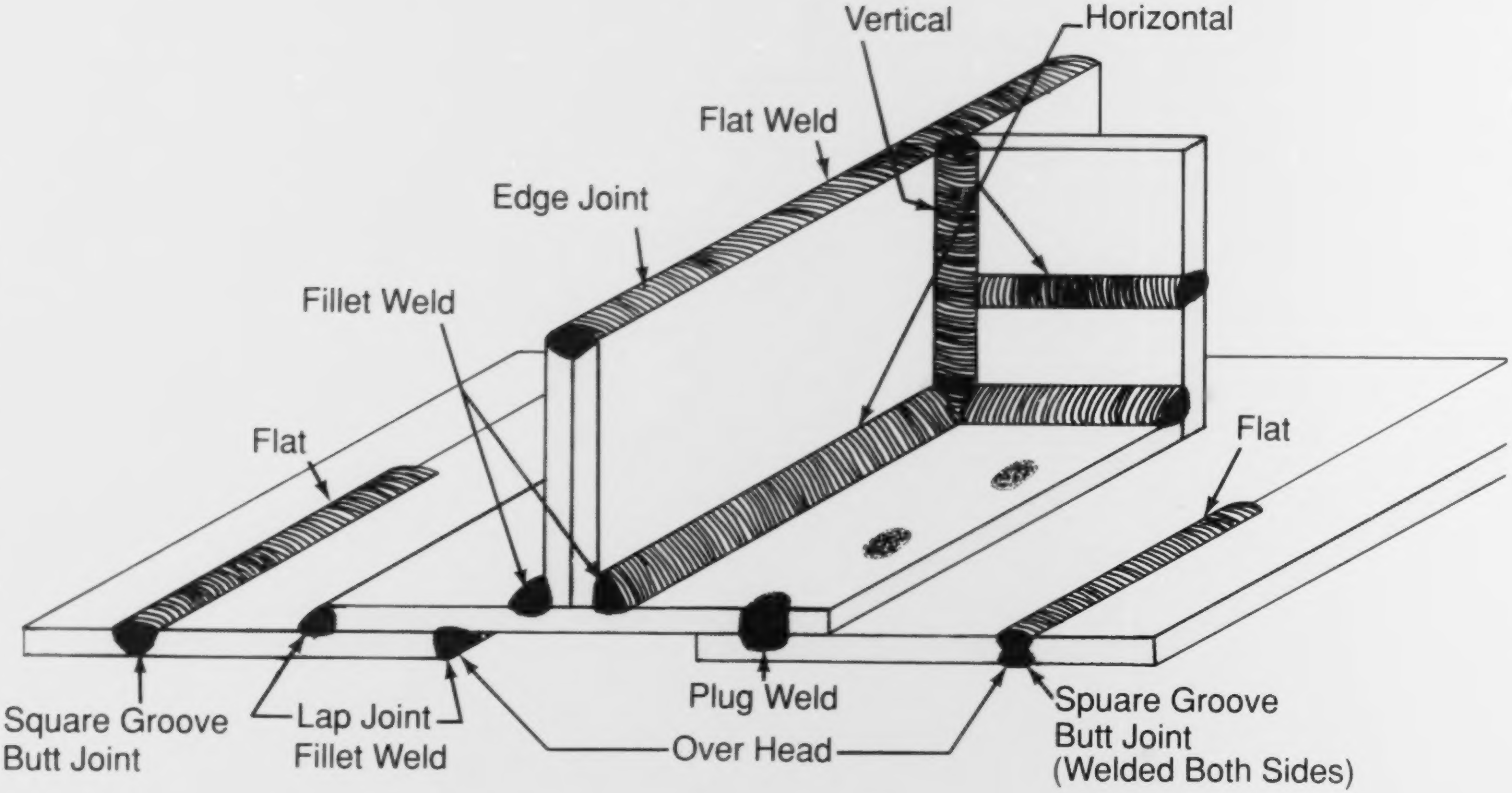
CAST IRON

		1/8" SIZE	5/32" SIZE	3/16" SIZE	1/4" SIZE
ESt	DC(+), AC	80-100			
ENi-Cl	DC(±) AC	60-110 65-120	100-135 110-150		

Basic Motions for Electrode Manipulation

Motion	Illustration	Typical Uses
Straight whipping motion		Used with fast-fill electrodes to make stringer beads in all positions and on all types of joints
Whipping motion with slight weave in crater		Can be used with fast-fill electrodes on the first pass of vertical fillets and V-butts
Vertical side-to-side weave		Used with all types of electrodes to make fill passes on vertical fillets and V-butts; sometimes used with fill-freeze and low-hydrogen electrodes for first pass on fillets and V-butts
Triangular weave		Used with fill-freeze and low-hydrogen electrodes to make first pass on vertical fillets and V-butts
Box weave		Used with all types of electrodes to make fill passes on vertical fillets and V-butts, and has a distinct pause and slight upward motion at each edge of the weld
Circular motion		Used with all types of electrodes to make overhead welds, and is sometimes used with a slight whip after each circular motion in the crater
Flat side-to-side weave		Used with all electrodes on wide fillets and butts in the flat position

Typical Welded Joints and Positions


Vertical
Horizontal
Flat Weld
Edge Joint
Fillet Weld
Flat
Flat
Square Groove
Butt Joint
Lap Joint
Fillet Weld
Over Head
Plug Weld
Spuare Groove
Butt Joint
(Welded Both Sides)

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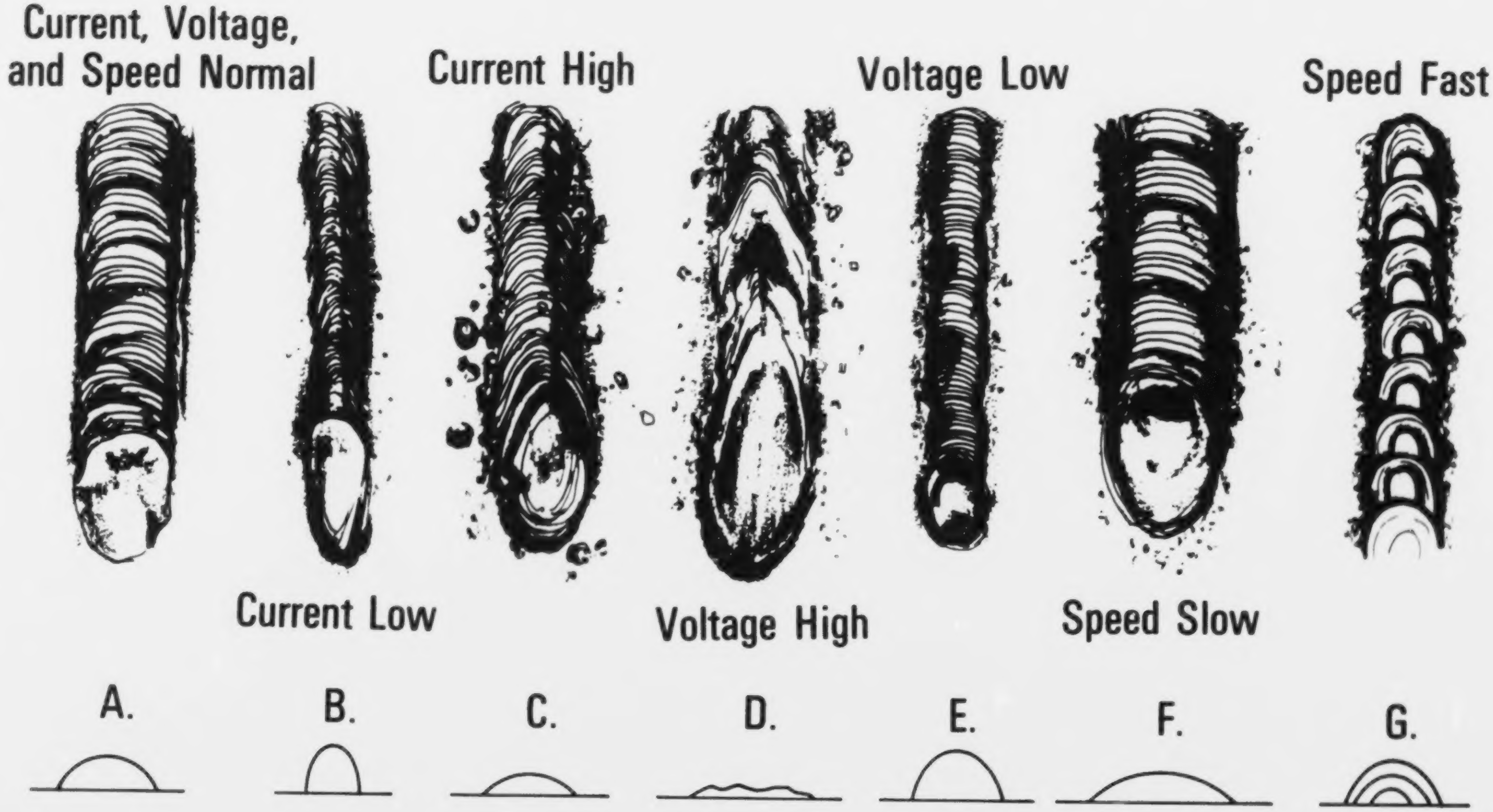
TM 6

Good and Bad Welds


Current, Voltage, and Speed Normal
Current Low
Current High
Voltage High
Voltage Low
Speed Slow
Speed Fast
A.
B.
C.
D.
E.
F.
G.

Equipment, Applications, and Techniques
Unit 2

Information Sheet

1. **Terms and definitions**

    a. **Air contaminants** — Hydrogen, oxygen, and nitrogen in air

    b. **Axis of a weld** — A line through the length of a weld, perpendicular to the cross-section at its center of gravity

    c. **Cap pass** — The final bead or beads needed to complete a welded joint

    d. **Deposition rate** — The weight of material deposited in a unit of time

    e. **Filler pass** — The remainder of the beads required to complete the joint from the root bead out to the cap pass

    f. **Root bead** — A weld bead that extends into or includes parts or all of the joint root

    g. **Shielding** — Any procedure or device for protecting an in-process weld from atmospheric contamination

    h. **Slag** — A nonmetallic product resulting from the mutual dissolution of flux and nonmetallic impurities in some welding and brazing processes

    i. **Stringer bead** — A type of weld bead made without appreciable weaving motion

2. **Advantages of SMAW**

    a. Equipment is relatively inexpensive.

    b. Equipment is portable because the welding machines can be powered with gasoline or diesel powered engines.

    c. Applications are relatively simple and can be adapted to many job requirements.

    d. SMAW is well suited for maintenance and repair work in small shops, on farms, and in garages.

Information Sheet

3. Principles of SMAW

a. An electric arc is struck between a grounded base metal and a flux-covered electrode held in a holder and manipulated by hand.

b. The heat of the arc melts the base metal and the metal in the electrode so that the two fuse together to create the weld.

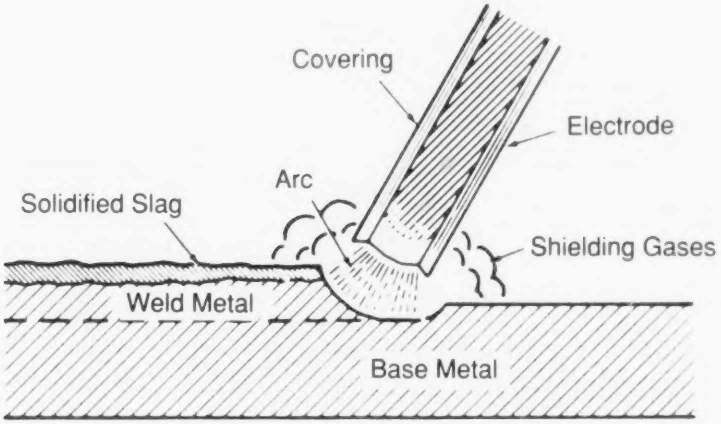
c. Flux contained on the electrode covering is also melted or vaporized to provide shielding that protects the weld from contaminants in the air, hence the name shielded metal arc welding.

4. Relationships of arc, base metal, electrode, and flux

a. The arc stream is created by holding an electrode approximately ⅛" away from the base metal.

b. The arc stream creates a molten pool or crater that tends to flow away from the arc and cool and solidify as it moves.

c. Flux from the electrode covering forms a slag on the top of the weld to protect it from contaminants during cooling.



Courtesy Lincoln Electric Company

Information Sheet

5. How flux-covered electrodes work

a. Flux-covered electrodes have a core of metal wire with a baked on chemical covering, and both parts of the electrode have specific functions.

b. The wire core melts in the arc stream and droplets of metal are transferred across the arc to make the molten puddle and provide the filler metal to fill the gap or groove between two base metals.

c. The flux covering also melts in the arc stream to stabilize the arc, to provide a shield around the arc to keep it free from atmospheric impurities, and to form a slag covering to protect the weld.

6. Benefits of learning SMAW

a. SMAW introduces a beginner to the basics of other arc welding processes.

b. SMAW acquaints the beginner with the welding machines and electrical accessories used in other arc welding processes.

c. SMAW introduces the beginner to the world of electrodes and their relationship to metal thicknesses, welding speeds, and amperage requirements.

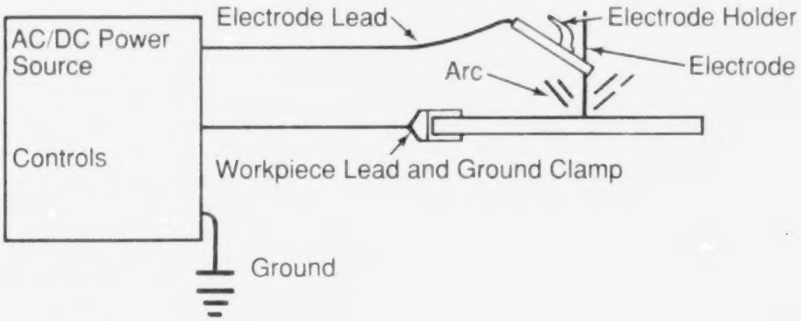
d. SMAW acquaints the beginner with the basic concepts of shielding and how shielding improves and protects a weld.

e. SMAW helps the student develop the manual dexterity required to work with other arc welding processes.

f. SMAW gives the beginner an added welding skill that will add versatility to job-getting resumes.

7. Welding machines and their electrical characteristics

a. Basic circuit — Current must travel in a complete loop from the power supply to the arc and back to the power supply, and the circuit must be grounded.



Information Sheet

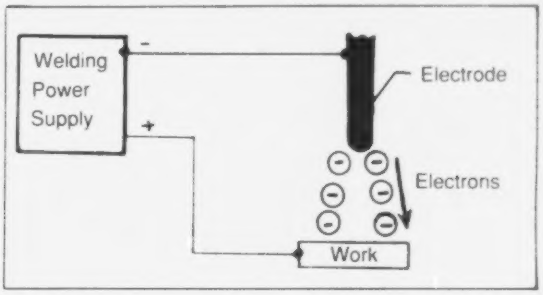
b. Polarity — This is the direction that current flows through a basic welding circuit, and is expressed as negative or positive in relation to DC current.

c. AC (alternating current) — This is current that alternates from one direction to another 60 times per second, and is expressed as 60 Hertz.

d. DC (direct current) — This is current that flows in only one direction.

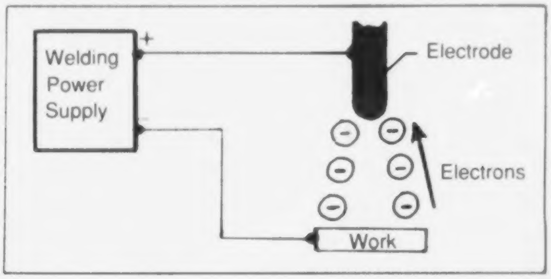
e. DCEN (direct current, electrode negative) — This is produced by a negative electrode and a positive workpiece that causes the current to flow from the electrode to the workpiece.

Note: DCEN was formerly termed DCSP, direct current, straight polarity.



f. DCEP (direct current, electrode positive) — This is produced by a positive electrode and a negative workpiece that causes the current to flow from the workpiece to the electrode.

Note: DCEP was formerly termed DCRP, direct current, reverse polarity.



Information Sheet

8. Welding machine performance characteristics and their applications

a. AC transformer — These machines change high-voltage, low-amperage AC to low-voltage, high-amperage AC in machines that usually have a 220/240 volt input current.

b. AC or DC transformer-rectifier — These machines change high-voltage, low-amperage AC to low-voltage, high-amperage AC or DC, and these machines are ideal for adjustment to different materials and welding positions.

c. DC generator (motor or engine) — In these machines, current varies with the speed the armature turns, polarity changes may be made by flipping a switch or reversing weld connections, and some of these machines are powered with AC motors while others are powered with gas or diesel engines.

d. Duty cycle — Sizes of welding machines are rated in accordance with their amperage capacity at 60 percent duty cycle.

Example: A welding machine rated at 200, 250, 300, etc., will only put out the rated amperage and rated voltage for six out of every ten minutes. The machine must be idle and allowed to cool for the other four minutes.

9. Basic SMAW accessories and their purposes

a. Cables are insulated copper, extra-flexible leads that carry the current from the power source to the electrode, and they vary in size or diameter according to machine capacity and length requirements.

Table 2.1
Recommended Copper Welding Cable Sizes

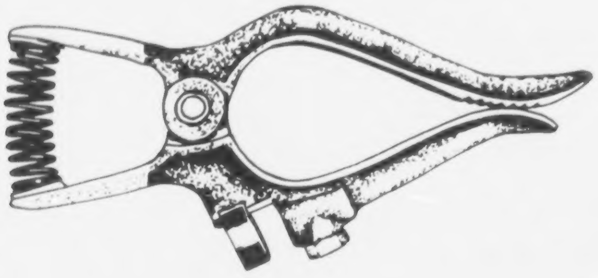
Power Source		Awg Cable Size for Combined Length of Electrode and Ground Cables				
Size in Amperes	Duty Cycle, %	0 to 50 ft (0 to 15 m)	50 to 100 ft (15 to 30 m)	100 to 150 ft (30 to 46 m)	150 to 200 ft (46 to 61 m)	200 to 250 ft (61 to 76 m)
100	20	6	4	3	2	1
180	20 30	4	4	3	2	1
200	60	2	2	2	1	1/0
200	50	3	3	2	1	1/0
250	30	3	3	2	1	1/0
300	60	1/0	1/0	1/0	2/0	3/0
400	60	2/0	2/0	2/0	3/0	4/0
500	60	2/0	2/0	3/0	3/0	4/0
600	60	2/0	2/0	3/0	4/0	*

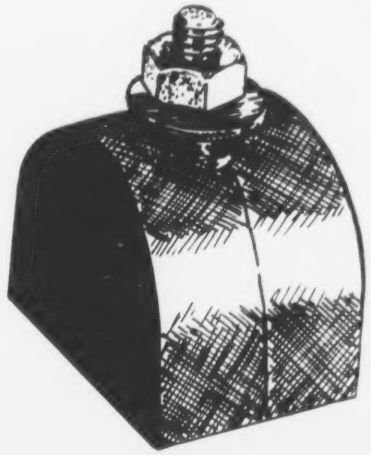
* Use two 3/0 cables in parallel

Courtesy American Welding Society

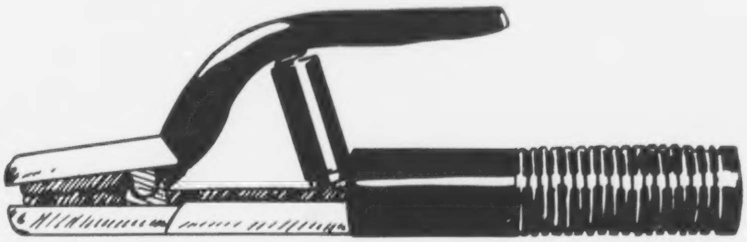
Information Sheet

b. Clamps are used to fasten the cables to workpiece or table where the workpiece is positioned so the welding circuit will be completed, and some operate with spring pressure while others are magnetic.





c. Electrode holders are hand-held clamping devices that hold the electrode during the welding process; they should be selected according to the machines maximum output rating, and they should be well insulated, lightweight to keep a welder from tiring, and sturdy enough to stand up under continued use.



SPECIFICATIONS

TWECOTONG Model	Amp Cap	Alloy	Electrode Capacity	Type — Capacity Cable Connection	Weight	Length
A-532	200	98% Copper	thru 5/32"	Ball-Point thru 2/0	14 ozs.	8½"
A-316	250	98% Copper	thru 3/16"	Ball-Point thru 2/0	16 ozs.	9½"
A-732	300	98% Copper	thru 7/32"	Ball-Point thru 2/0	18 ozs.	10"
AL-300	300	Forged Aluminum	thru ¼"	Ball-Point thru 2/0	14 ozs.	10"
A-14	350	98% Copper	thru ¼"	Ball-Point thru 4/0	24 ozs.	11"
AL-400	400	Forged Aluminum	thru ¼"	Double Ball-Point thru 4/0	16 ozs.	11¼"
A-14 HD	400	98% Copper	thru ¼"	Double Ball-Point thru 4/0	30 ozs.	12"
A-38-HD	500	98% Copper	thru ⅜"	Double Ball-Point thru 4/0	34 ozs.	13¼"

Courtesy Tweco

Information Sheet

10. AWS electrode classifications for mild steel and low alloy electrodes

a. The prefix "E" designates an "electric" arc welding electrode

b. The first two digits of 4-digit numbers and the first three digits of 5-digit numbers indicate minimum tensile strength.

Examples:	E60XX	60,000-psi Tensile Strength
	E70XX	70,000-psi Tensile Strength
	E110XX	110,000-psi Tensile Strength

c. The next-to-last digit indicates position.

Examples:	EXX1X	All positions
	EXX2X	Flat positions and horizontal fillets

d. The last digit (0 through 8) together with the next-to-last digit indicate the type of covering and current to be used; mild steel electrodes are also classified as fast-freeze, fill-freeze, fast-fill, and low hydrogen.

e. The last letter and digit (EXXXX-A1) indicate the approximate alloy in the deposit.

Examples:	-A1	½% Mo
	-B1	½% Cr, ½% Mo
	-B2	1-¼% Cr, ½% Mo
	-B3	2-¼% Cr, 1% Mo
	-C1	2-½% Ni
	-C2	3-¼% Ni
	-C3	1% Ni, 35% Mo, 15% Cr
	-D1 & D2	.25-.45% Mo, 1,25-2.00% Mn
	-G	.50 min Ni, .30 min Cr., .20 min Mo, .10 min V (Only one of the listed elements is required.)

f. In addition to the AWS classification system, electrodes are also classified according to diameter expressed in fractions of an inch.

Information Sheet

11. Stainless steel and other alloy electrodes and their classifications

a. Stainless steel electrodes are numbered to match specific types of stainless steel because the chemical composition of the electrode must match the alloys in the stainless.

b. With other alloy electrodes, chemical symbols precede the digits to indicate significant alloys in the electrode.

Examples: ECuSI means electrical electrode
Cu means copper
SI means silicon

ECuNI means electrical electrode
Cu means copper
NI means nickel

12. Basic elements of arc welding and their importance

a. Electrode selection must be related to both the type and thickness of a base metal, and one rule of thumb is that electrode diameter should not exceed the thickness of the base metal.

b. Welding speed is the greatest factor in reducing welding costs, and one rule of thumb is to use the largest allowable electrode at the highest acceptable amperage.

c. In welding positions for vertical, overhead, and horizontal butt welds, the maximum size for an E6010 or E6011 is 3/16", and for these same positions with a low-hydrogen electrode, the maximum size is 5/32".

d. For joint preparation, a narrow V-groove in a butt joint will usually prevent the use of a large electrode on the first pass.

e. With fit-up, backup strips are permitted with most codes.

f. Machine capacity is important because amperage ratings on some welding machines may not be large enough to properly handle large electrodes.

g. Amp settings are always determined by electrode selection and welding position, and the rule of thumb is to turn your amps down when welding vertical up and to turn your amps up when welding vertical down.

h. The rule of thumb for voltage changes between the electrode and the base metal is that a long arc increases voltage and a short arc decreases voltage.

i. Polarity is determined by electrode selection, and correct polarity is extremely important in DC electric arc welding processes.

Information Sheet

13. Electrode angles and their meanings

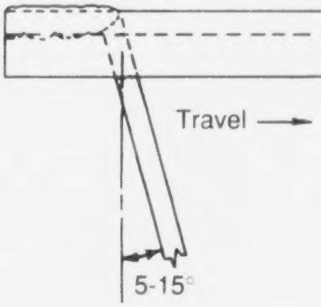
a. Electrode angles express two vital elements:

   (1) The relationship of an electrode to the axis of the weld.

   (2) The relationship of an electrode to the surface or surfaces of a workpiece.

b. Travel angle is the angel of an electrode in relation to the axis of a weld when the electrode is perpendicular to the axis.

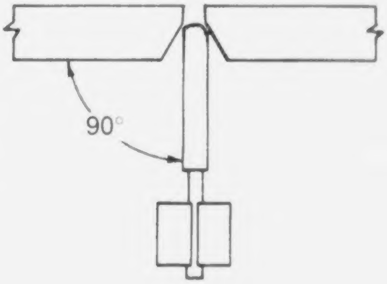
   Note: In the job sheets that follow, travel angle is usually presented in a side view.



Side View

c. Work angle is the angle of an electrode in relation to the surface or surfaces of a workpiece when the electrode is perpendicular to the axis of the weld.

   Note: In the job sheets that follow, work angle is usually presented in a front view.



Front View

Information Sheet

14. SMAW starting techniques

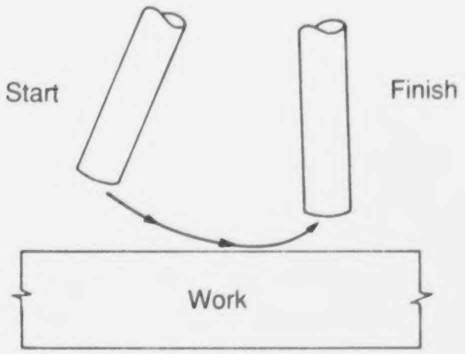
a. The technique most basic to all arc welding is to start and maintain an arc so that current is forced across the gap between the electrode tip and the base metal, and beginners should develop the skill of starting and maintaining an arc with a proper gap or arc length.

b. The "scratch method" for starting an arc is the simplest method for most beginners, and the scratch method works according to the following:

   (1) Move the electrode across the base metal at an angle like you would use to strike a match.

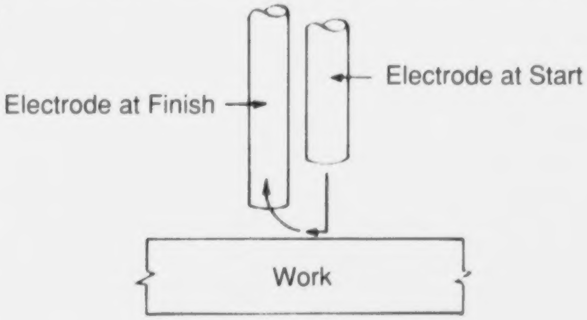
   (2) As the electrode scratches the base metal, an arc starts.

   (3) When the arc starts, raise the electrode slightly to make a long arc, and then return to normal arc length.



Courtesy Lincoln Electric Company

c. The tap method for starting an arc is accomplished by moving the electrode downward in a vertical direction until it just taps the base metal, then raising the electrode up slightly to form a long arc, then returning to normal arc length again.



Courtesy Lincoln Electric Company

Information Sheet

15. Techniques for controlling arc gap

a. Arc gap should usually be slightly less than the diameter of the electrode.

b. Too much gap can usually be identified by a hissing sound as opposed to a crackling sound.

c. Too much gap can be spotted visually because it causes excess spatter and poor penetration.

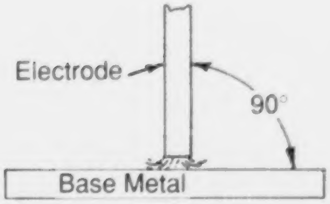
d. Too much gap will cause filler metal to melt off in large wobbly drops, and slag will be difficult to remove.

e. With too little gap, the arc will not start, or the electrode may freeze to the weld puddle and stick there.

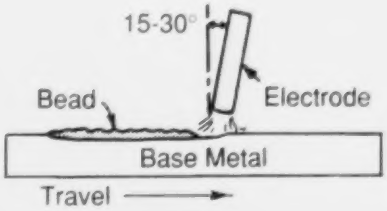
16. Techniques for using electrode angles

Note: Electrode angle will vary with electrode selection and welding position, but the following rules of thumb are good guidelines for beginners.

a. For right-hand welding of flat beads, place the electrode at 90° angle, then lean it 15° to 30° to the right so that it is pointed in the direction of travel, and for left-hand welding of flat beads, reverse the right-hand procedure.



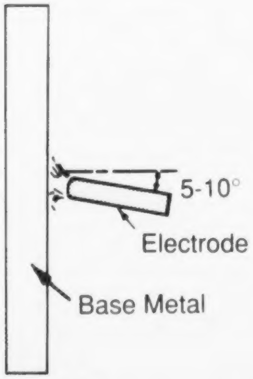
Front View



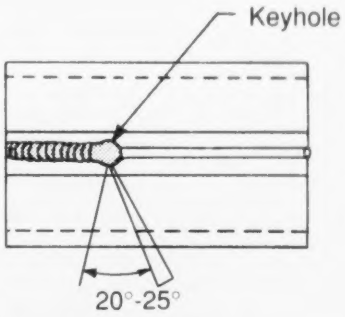
Side View

Information Sheet

b. When welding in the horizontal position, angle the electrode 20° to 25° in the direction of travel.

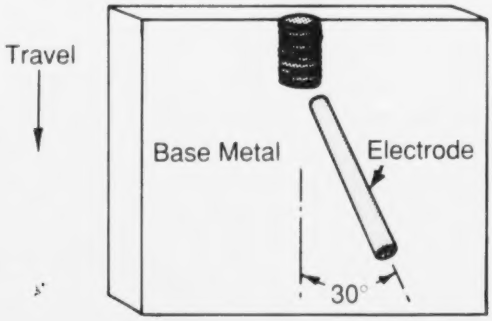

5-10°
Electrode
Base Metal

Front View

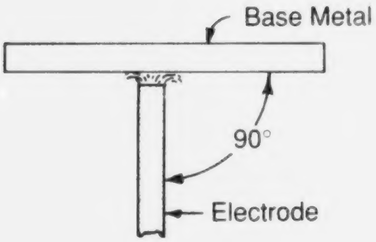

Keyhole
20°-25°

Side View

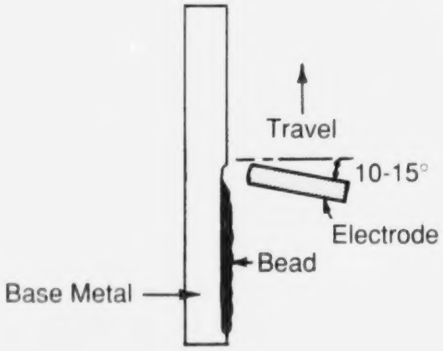
c. When welding in the vertical down position, point the electrode up at an angle of about 30° from the base metal.


Travel
Base Metal
Electrode
30°

d. When welding in the vertical up position, hold the electrode 10° to 15° below perpendicular and at a 90° angle from the base metal.


Base Metal
90°
Electrode

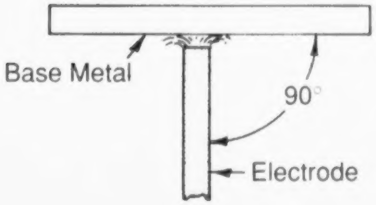
Top View


Travel
10-15°
Electrode
Bead
Base Metal

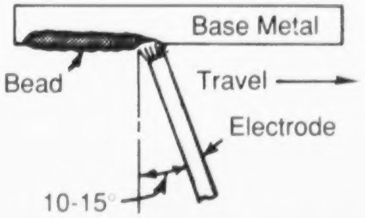
Side View

Information Sheet

e. When welding in the overhead position, hold the electrode perpendicular to the base metal at 90° and incline it 10° to 15° in the direction of travel.



Front View



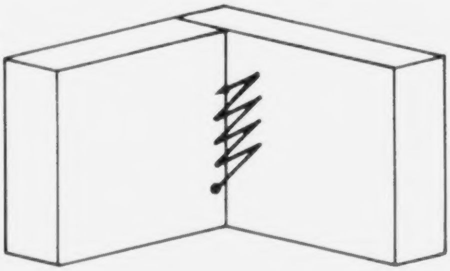
Side View

17. **Bead running techniques and their procedures**

a. Drag — Used with high-deposit, fast-fill electrodes and consists of lightly dragging the electrode tip along the base metal to force the molten filler metal uniformly out from under the electrode tip which in turn provides good penetration

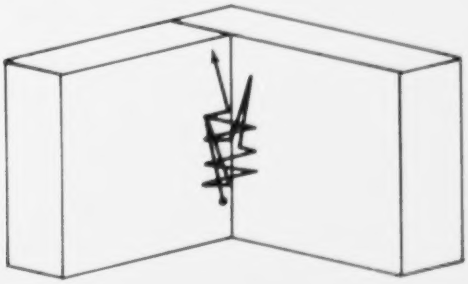
Note: When perfected, the drag technique can produce welds so smooth and uniform they look as if they were machine made.

b. Whipping — Used with fast-freeze electrodes to make stringer beads in all positions and on all types of joints, and consists of maintaining a short arc when in the crater and a long arc as the electrode is drawn out of the crater so the molten pool will stay small and allow the filler metal to freeze quickly so the metal does not spill through the joint

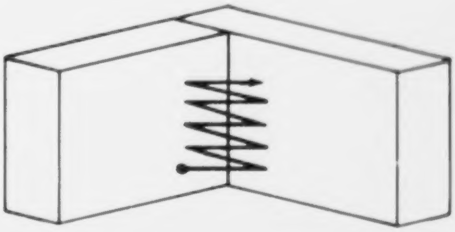


Information Sheet

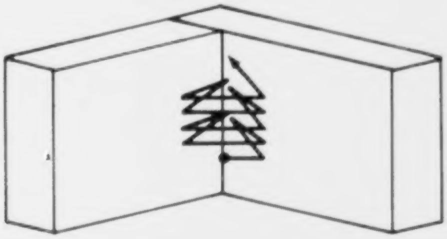
c. Whipping with slight weave in crater — Can be used with fast-freeze electrodes to make the first pass on vertical fillet and V-groove butt welds



d. Side-to-side weave — Used with all types of electrodes to make fill passes on vertical fillet and V-groove butt welds, and also sometimes used with fill-freeze and low-hydrogen electrodes to make the first pass on these joints

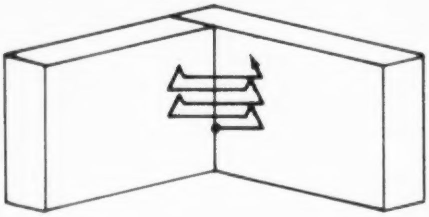


e. Triangular weave — Used with fill-freeze and low-hydrogen electrodes to make the first pass on vertical fillet and V-groove butt welds because it provides a larger weld than a side-to-side weave

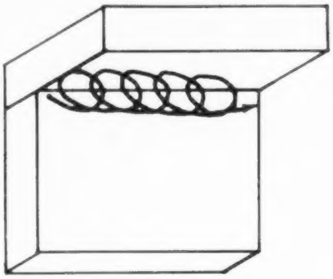


Information Sheet

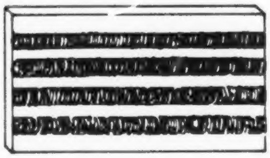
f. Box weave — Used with all types of electrodes to make the fill pass on vertical fillet and V-groove butt welds, and is similar to the side-to-side weave, but with a distinct pause and slight upward motion at each edge of the weld to assure complete crater fill-up and eliminate undercutting



g. Circular motion — Used will all types of electrodes to make overhead welds



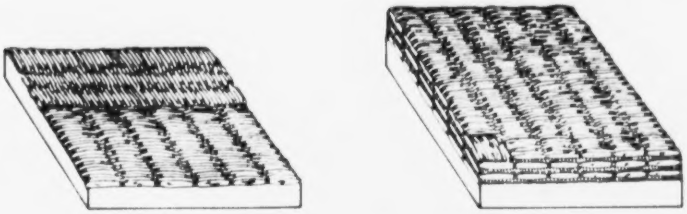
h. Stringer bead — A single, straight bead used with certain types of electrodes, and consists of a drag or whipping motion used in all welding positions



Courtesy Lincoln Electric Company

Information Sheet

i. Padding — Used with all types of electrodes to build up metal surfaces with one or more layers of weld beads, and can be used on either flat or curved surfaces as overlapping straight beads or overlapping weave beads



Courtesy Lincoln Electric Company

18. Technique for stopping and restarting an arc

a. Anticipate the point where the rod is going to be used up or where welding will stop.

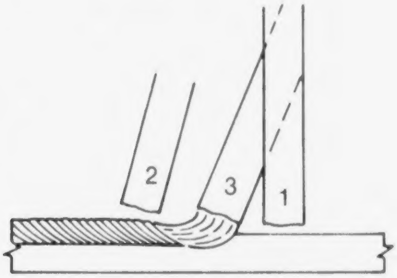
b. Stop the forward motion of the electrode.

c. Gradually withdraw the electrode to break the arc.

d. Chip the slag off the end of the weld about ¼″ to ½″ back.

e. Restart the arc about ½″ in front of the forward end of the crater.

f. Move the electrode quickly back to the back crown of the crater and immediately resume welding in the direction of travel.



Courtesy Lincoln Electric Company

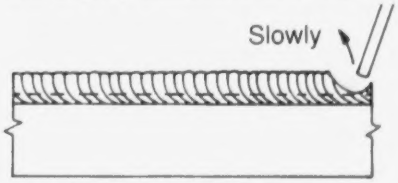
g. If the stop/restart procedure is properly executed, any marks left by restarting the arc ahead of the crater will be covered as the weld bead is continued.

Information Sheet

19. **Techniques for filling a crater at the end of a weld**

   a. Option 1:

      (1) Just before the bead reaches the end of the plate, draw the electrode slowly up and slightly backward over the completed weld.



Courtesy Lincoln Electric Company

      (2) Make sure the motion is slow enough to allow the crater to fill and that the backward motion is far enough that the crater remains on top of the bead about ¼" to ½" back from the end of the weld.

   b. Option 2:

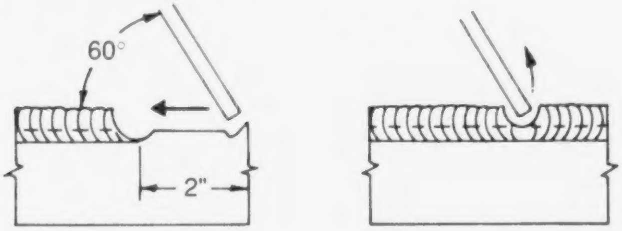
      (1) Break the arc about 1" or 2" from the end of the weld by quickly shortening the arc and pulling it sideways out of the crater.

      (2) Chip and remove slag from the end of the bead.

      (3) Move to the end of the plate, restart the arc, and weld back toward the bead.

      (4) Incline the electrode about 60° in the direction of travel.

      (5) Weld back over the crater and stop the arc by pulling up and slightly backward as the two beads run together and the crater forms properly on top of the bead.



Courtesy Lincoln Electric Company

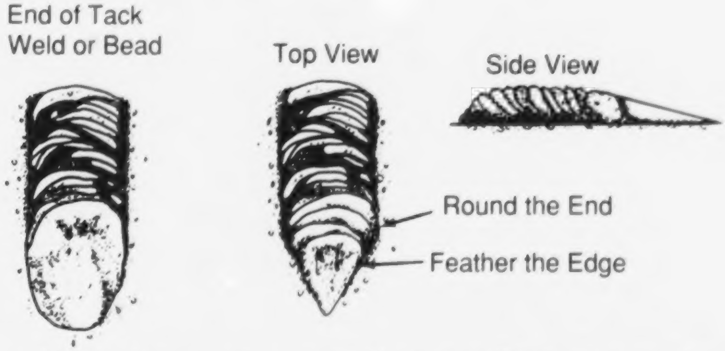
Information Sheet

20. Guidelines for using feathered edges for tie-ins

a. To assure a good tie-in when restarting a bead or when starting from a tack weld, the tie-in point should always be chipped and brushed.

b. When a weld deposit is too large to make a normal tie-in, the end of the first bead or the end of the tack weld should be ground and feathered.

c. Grinding and feathering means using a hand grinder to smoothly round the sides near the end of the bead or tack weld, then grinding the end of the bead to a sloping, sharp edge.



d. Grinding and feathering sometimes called for in specifications, is used on some root passes in pipe welding, and is necessary on some V-groove welds.

21. Basic steps in joint preparation

a. Beveling requires putting angels on pieces of material so that when they are joined, the weld will get good penetration below the surface of the base metal

Note: Bevels may be machined, but the most common method is to use an oxyacetylene cutting torch.

b. Grinding requires the use of an abrasive device, usually a portable grinder, to remove metal or slag from the weld area

Note: Although grinding may be used to bevel plates, it is mostly used to clean slag off a weld area after cutting or welding and for grinding and feathering edges for tie-ins.

Information Sheet

22. Good and bad welds and their characteristics

a. Current, voltage, and speed normal — Smooth well-formed bead with no undercutting, overlapping, or piling of slag

b. Current low — Poor penetration, slow progress, excessive piling of weld metal, and slag inclusion

c. Current high — Excessive spatter and undercutting of weld joints

d. Voltage high — Poor penetration with flat bead, weld zone not shielded

e. Voltage low — Poor penetration and humped bead

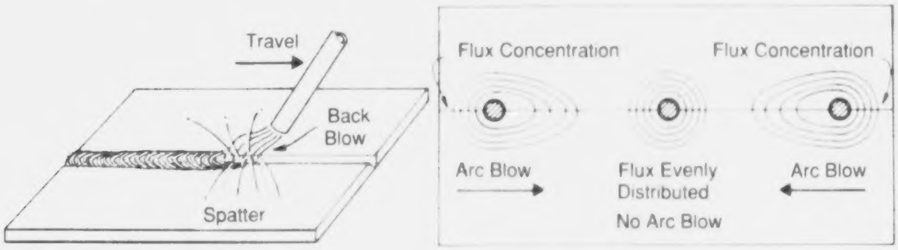
f. Speed slow — Excessive heat and weld metal reinforcement leading to unnecessary distortion of joint

g. Speed fast — Irregular bead, poor penetration, undercut, and not enough weld metal in joint, causing a weak joint

23. Causes of and remedies for arc blow

a. Arc blow is caused when magnetic forces present in DC build up lines of magnetism around the arc and cause the arc to blow wildly forward, back, or to one side, and spatter badly.

b. Arc blow can be caused by high amperage, and the major problem areas are thick plates, corners, deep grooves, and the start and finish of joints.



Courtesy Lincoln Electric Company

c. Remedies for arc blow include:

  (1) Reduce current or switch polarity.

  (2) Change current to AC.

Information Sheet

(3) Change location of the ground clamp.

(4) Wrap ground cable around the workpiece and pass ground current through it to neutralize the magnetic field.

(5) Maintain a short arc.

24. Causes of and remedies for pinholes and porosity

a. Both pinholes and porosity can be caused when arc length is too long and travel speed is too fast.

b. Other causes of pinholes and porosity are faulty electrodes, incorrect polarity, surface conditions of the base metal, or high sulphur and other impurities.

c. Remedies for pinholes and porosity include using a shorter arc length and keeping the puddle molten for a longer period so that the gases may boil out before the metal freezes.

d. Other remedies include using dry electrodes and cleaning the surfaces of base metals.

25. Causes of and remedies for undercutting

a. Undercutting is usually caused by too high a current or too long an arc length.

b. Undercutting can also be caused by improper rod angle manipulation or too fast a welding speed.

c. Remedies for undercutting include reducing the current and shortening the arc length.

d. Other remedies would be to use a smaller diameter electrode or change the electrode angle so that the force of the arc will help fill the undercut.

26. Causes of and remedies for weld spatter

a. Weld spatter is caused by too high a current (amps) or too long an arc length.

b. The remedies for weld spatter are to reduce current and shorten the arc length.

27. Causes of and remedies for incomplete penetration

a. Incomplete penetration can be caused by a faulty joint design, but can also be caused by insufficient welding current, too large an electrode, or too fast a welding speed.

Information Sheet

b. One remedy for incomplete penetration is to check the joint carefully, including the root opening, root face dimension, and the groove face angle.

c. If the joint is not faulty, other remedies include increasing the weld current, reducing welding speed, and using a smaller diameter electrode.

28. Causes of and remedies for slag inclusion

a. Slag inclusion can be caused by a sharp, V-shaped recess in the joint design.

b. Other causes of slag inclusion are high flow rate of molten metal, rapid chilling, or a weld current that is too low.

c. The remedy for slag inclusion sometimes calls for using preheating and a higher welding current or increasing the size of the weld area to allow the weld to tie in completely with the base metal.

29. Causes of and remedies for excessive weld reinforcement

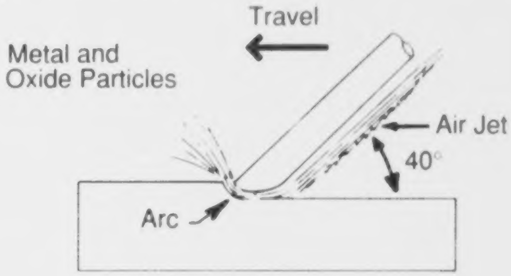
a. Weld reinforcement is usually caused by too slow a travel speed or the wrong electrode size, but it can also be caused by poor electrode movement.

b. The remedies for excessive weld reinforcement include choosing the correct electrode and increasing travel speed and maintaining good electrode movement.

30. Principles of air carbon arc cutting (CAC-A)

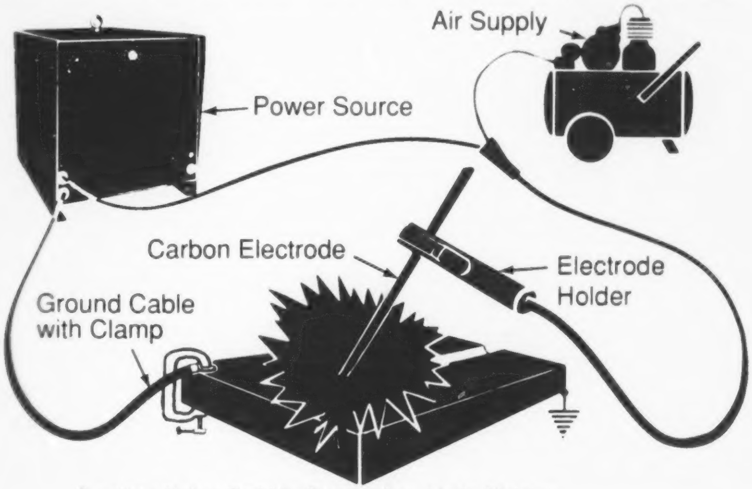
a. CAC-A is a cutting process that cuts or gouges metal by using an electric arc between a carbon electrode and a base metal.

b. As the arc melts the base metal, a controlled stream of compressed air is directed at the arc to remove molten metal to make a complete cut or produce a groove.



Information Sheet

c. Equipment needed for CAC-A includes a power supply, ground cable with clamp, carbon electrodes, an air carbon arc torch, and a supply of compressed air.



Courtesy Union Carbide Corporation, Linde Division

31. CAC-A power sources

a. Standard power sources for arc welding can be used for CAC-A, but an opening circuit voltage of at least 60 volts is required.

Type of Current	Type of Power Source	Remarks
DC	Variable-voltage motor-generator, rectifier, or resistor-grid equipment	Recommended for all electrode sizes.
DC	Constant-voltage motor-generator or rectifier	Recommended only for electrodes above ¼" diameter.
AC	Transformer	Should be used only with AC electrodes.
AC-DC	Rectifier	DC supplied by three-phrase transformer-rectifier is satisfactory. DC from single-phase source not recommended. AC from AC-DC power source is satisfactory if AC electrodes are used.

Courtesy Union Carbide Corporation, Linde Division

Information Sheet

b. Air pressure required to make a cut depends on the diameter of the carbon electrode, and air pressures usually range from a minimum of 40 psi to 80 psi and above.

Maximum Electrode Size (in.)	Application	Pressure (psi)	Consumption (cfm)
1/4	Intermittent-duty, manual torch	40	3
1/4	Intermittent-duty, manual torch	80	9
3/8	General-purpose	80	16
3/4	Heavy-duty	80	29
5/8	Semiautomatic mechanized torch	80	25

Courtesy Union Carbide Corporation, Linde Division

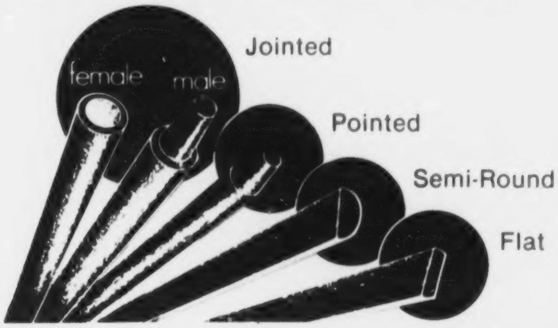
32. Types of CAC-A electrodes and their characteristics

a. Copper-coated — Made of graphite (carbon) for DC operation in sizes from 5/32" to 1"

b. Flux-coated steel — Used for cutting or gouging high-purity copper or cast iron and available with a 1/4" diameter and 18" long

Information Sheet

c. Graphite — Electrode has no copper coating, which tends to make the electrode "pencil" or cause a gradual decrease in the size of a groove



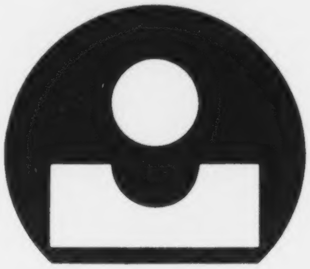
Material	Electrode	Power
Steel	DC AC	DCRP AC
Stainless Steel	DC AC	DCRP AC
Iron (cast iron, ductile iron, malleable iron)	AC DC	AC or DCSP DCRP (high-amperage)
Copper Alloys	AC DC	AC or DCSP DCRP
Nickel Alloys	AC	AC or DCSP

Courtesy Union Carbide Corporation, Linde Division

33. CAC-A electrode shapes and their uses

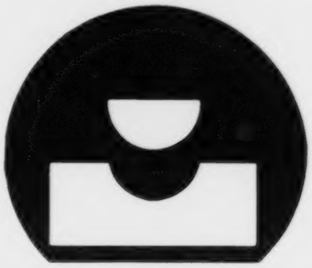
Note: Illustrations courtesy Union Carbide Corporation, Linde Division.

a. A round electrode is used to gouge a U groove.

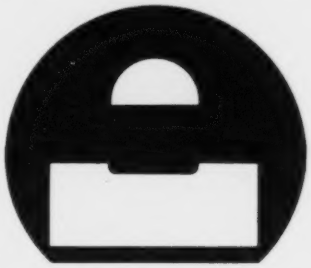


Information Sheet

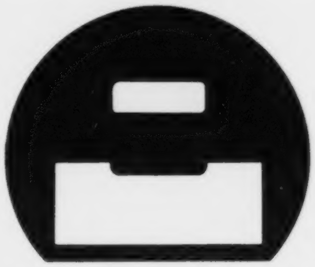
b. A semi-round electrode can also be used to gouge a U groove.



c. A semi-round electrode can also be turned to gouge a flat groove.



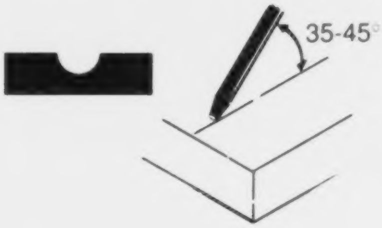
d. A flat electrode is used to make a flat groove.



34. CAC-A electrode angles and their uses

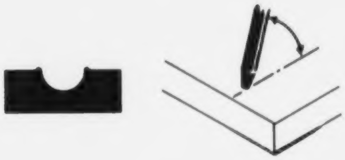
Note: Illustrations courtesy Union Carbide Corporation, Linde Division.

a. 35° to 45° between electrode and work — The preferred angle for gouging

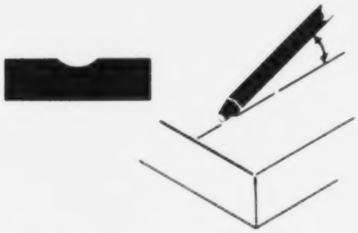


Information Sheet

b. More than 45° between electrode and work — A nonpreferred angle that is higher and causes the groove to cut deeper into the base metal and impair metal removal



c. Less than 35° between electrode and work — A nonpreferred angle that is lower and causes the groove not to cut as deeply into the base metal



35. Amperage selection for gouging

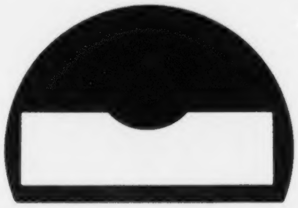
Note: Illustrations courtesy Union Carbide Corporation, Linde Division.

a. Amperage should be selected according to power source and electrode size.

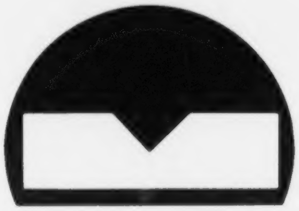
Type of Electrode and Power	Maximum and Minimum Current (amp)					
	Electrode Size (in.)					
	5/32	3/16	1/4	5/16	3/8	1/2
DC Electrodes, DCRP Power	90-150	150-200	200-400	250-450	350-600	600-1000
AC Electrodes, AC Power	--	150-200	200-300	--	300-500	400-600
AC Electrodes, DCSP Power	--	150-180	200-250	--	300-400	400-500

Information Sheet

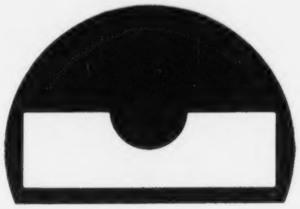
b. When amperage is lower than recommended, the groove will retain a U shape, but it will be shallow.



c. When the amperage is higher than recommended, approximately 15 percent higher, the groove will change from a U to a V shape.



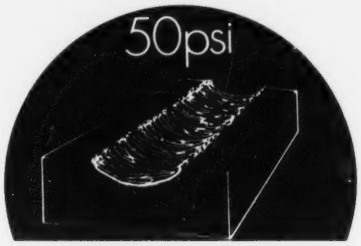
d. When amperage is set as recommended, the groove will have a uniform U shape with good depth.



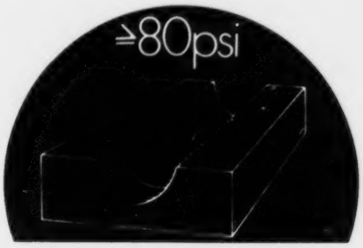
36. Air pressure and how it affects gouging

Note: Illustrations courtesy Union Carbide Corporation, Linde Division.

a. Low air pressure tends to produce an irregular surface and edge.



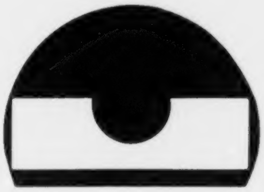
b. Correct air pressure allows for slag-free cuts.



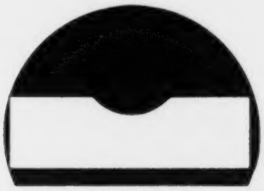
37. Travel speed and how it affects gouging

Note: Illustrations courtesy Union Carbide Corporation, Linde Division.

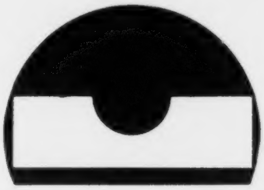
a. Slow travel speed generates more heat input into the base metal and produces a deeper groove.



b. High travel speed decreases metal removal, and as travel speed increases, metal removal decreases accordingly.



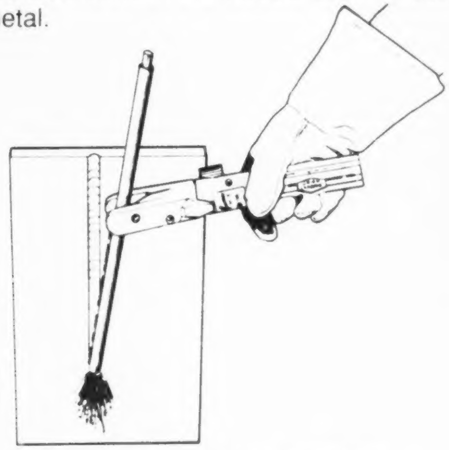
c. Correct travel speed produces a groove depth that is approximately half the diameter of the electrode.



Information Sheet

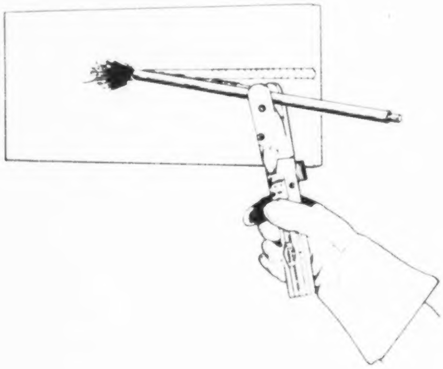
38. Techniques for gouging and their procedures

a. Vertical gouging should be done in the vertical down direction to allow for safe removal of moten metal.



Courtesy Union Carbide Corporation, Linde Division

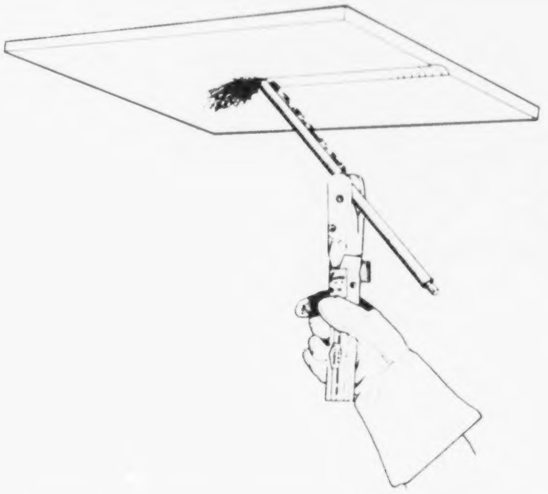
b. Horizontal gouging may be done left or right, but airstream must remain behind the electrode with respect to the direction of travel.



Courtesy Union Carbide Corporation, Linde Division

Information Sheet

c. Overhead gouging requires that the electrode be perpendicular to the base metal and angled so that molten metal will not drop on the operator.



Courtesy Union Carbide Corporation, Linde Division

39. Hardfacing

a. Hardfacing is a form of surfacing designed to increase the service life of machine parts whose edges and surfaces are subject to excessive wear from abrasion, impact, or corrosion.

b. Hardfacing can effectively restore parts subject to metal to ground wear—parts such as dozer blades and tillage parts on farm equipment.

c. Hardfacing can also restore parts subject to metal to metal wear—parts such as wheels on cranes and mine cars which are subject to continuous or repeated metal to metal impact.

40. Elements affecting hardfacing

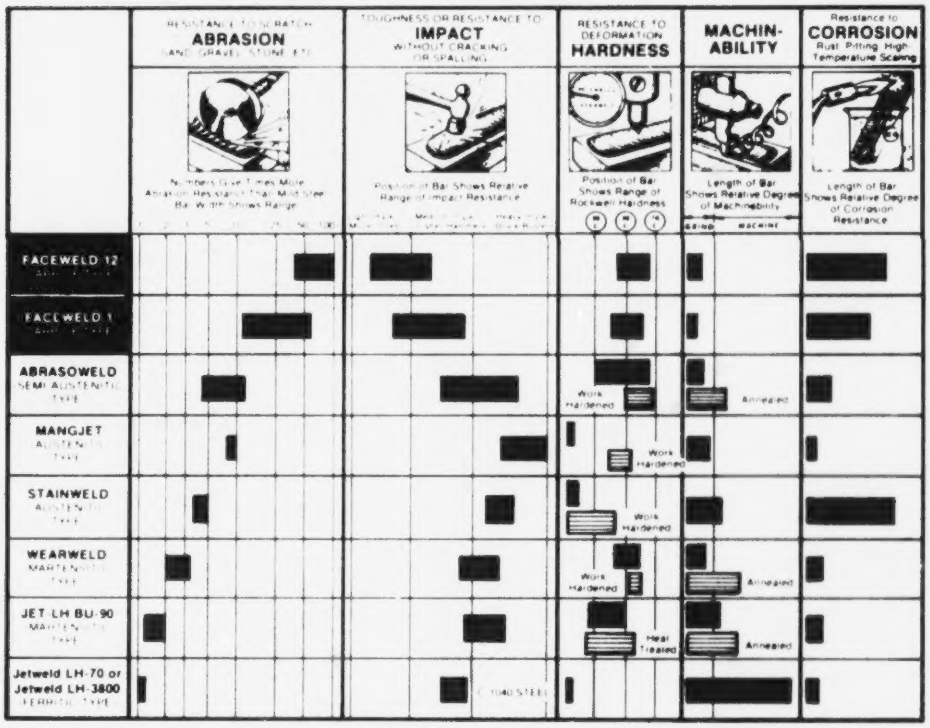
a. Hardfacing a worn part is usually less expensive than buying a new part, and the cost factor of hardfacing should always be considered.

b. It is important to know what kind of wear a part is subjected to so that hardfacing electrodes can be properly selected.

c. Knowing the base metal from which the part is made is vital to planning the hardfacing process required.

Information Sheet

d. The size of the part and number of surfaces that require hardfacing affect the cost of hardfacing.

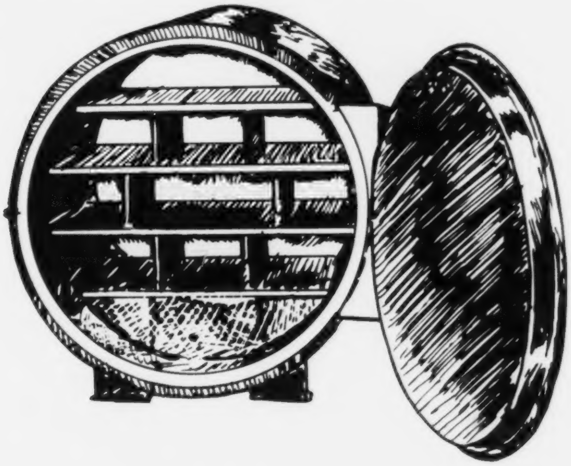


Courtesy Lincoln Electric Company

Information Sheet

41. Electrode drying ovens

a. Because moisture can change the chemical composition of some flux-covered electrodes, certain electrodes need to be stored in drying ovens and sometimes reconditioned or rebaked in a drying oven.



Type (AWS)	Air Conditioned Storage Before Opening RH = Relative Humidity	Dry Rod Oven Holding After Opening	After Exposure to Moisture a Sufficient Time to Affect Weld Quality	
			Recondition Step #1	Rebake Step #2
CELLULOSE EXX10 EXX11 EXX20 EXX30 **TITANIA** EXX12 EXX13	70°F-110°F (21°C-43°C) 50% MAX. RH	NOT RECOMMENDED	NOT RECOMMENDED	NOT RECOMMENDED
IRON POWDER M.S. EXX14 EXX24 EXX27	70°F-110°F (21°C-43°C) 50% MAX. RH	110°F-175°F (43°C-79°C)	1 HOUR @ 250°F-300°F (121°C-149°C)	½ to 1 HOUR @ 350°F (177°C)
			1½ TO 2 HOUR TOTAL	
IRON POWDER-LO-HYDROGEN EXX18 EXX28 **LO-HYDROGEN** EXX15 EXX16 **LO-HYDROGEN-HI-TENSILE** EXXX15 EXXX16 EXXX18	70°F-110°F (21°C-43°C) 50% MAX. RH	250°F-350°F (121°C-177°C)	1 HOUR @ 500°F-600°F (260°C-316°C)	½ HOUR @ 650°F-750°F (343°C-399°C)
			1½ HOUR TOTAL	
STAINLESS EXXX-15 EXXX-16	40°F-120°F (4.5°C-49°C) 60% (±10) RH	250°F-400°F (121°C-205°C)	1 HOUR @ 600°F (316°C)	NOT RECOMMENDED
INCONEL* MONEL* NICKEL HARD-SURFACING	40°F-120°F (4.5°C-49°C) 60% (±10%) RH	150°F-200°F (66°C-93°C)	1 HOUR @ 325°F-375°F (163°C-191°C)	1 HOUR @ 500°F-600°F (260°C-316°C)
			2 HOUR TOTAL	
BRASSES BRONZES	40°F-120°F (4.5°C-49°C) 60% (±10) RH	150°F-200°F (66°C-93°C)	NOT RECOMMENDED	NOT RECOMMENDED
GRANULATED OR AGGLOMERATED FLUX	40°F-120°F (4.5°C-49°C) 60% (±10%) RH	200°F-300°F (93°C-149°C)	NOT RECOMMENDED	2 HOURS @ 600°F-800°F (316°C-427°C)
FLUX CORED WIRE EXXT-1 EXXT-2 EXXT-5 EXXT-G	40°F-120°F (4.5°C-49°C) 60% (±10%) RH	200°F-300°F (93°C-149°C)	350°F-450°F (177°C-232°C)	NOT RECOMMENDED

Courtesy Phoenix Products Company, Inc.

b. Reconditioning or rebaking times should be as recommended by the drying oven manufacturer in relation to electrode type and relative humidity of storage area.

Equipment, Applications, and Techniques
Unit 2

Job Sheet 1—Start and Restart an Arc, Crater, and Backfill at the Edge While Running a Bead on Mild Steel Plate

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Equipment setup and safety	______
Start/restart technique	______
Crater/backfill technique	______
Weld quality	______

A. Tools and materials

SMAW machine with accessories
SMAW electrode(s) as selected by instructor
Mild steel plate as selected by instructor
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Welding helmet and safety glasses

B. Procedure

☐ 1. Inspect the work area to make sure it is free of flammable materials and well ventilated.

☐ 2. Note the location of the nearest fire extinguisher.

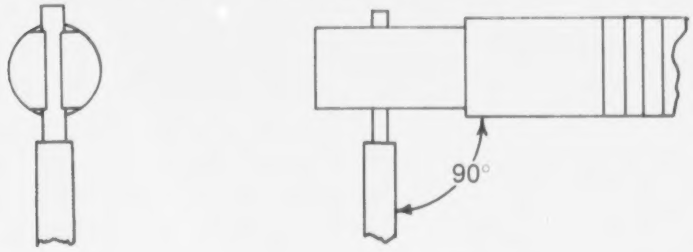
☐ 3. Attach the ground clamp to the worktable or workpiece.

☐ 4. Turn on SMAW machine.

☐ 5. Set machine to recommended amp setting and polarity, if needed.

Job Sheet 1

☐ 6. Place electrode in holder as indicated.



Front View Side View

☐ 7. Place the mild steel plate on a worktable directly in front of you.

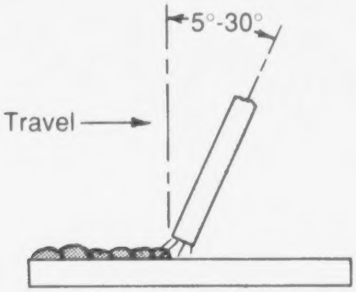
☐ 8. Move the electrode down close to the metal, being careful not to start an arc, then lower your welding hood to a safe operating position.

☐ 9. Start an arc with the scratch or tap method.

☐ 10. Withdraw the electrode just as the arc starts, form a long arc, then lower the electrode to a normal arc length that is slightly less than the diameter of the electrode you're using.

☐ 11. Make the bead while holding the electrode perpendicular to the plate at an angle of 15° to 30° in the direction of travel.

Note: If right-handed, weld from left to right, and if left-handed, weld from right to left.



☐ 12. Weld a bead about half the length of the plate, then purposely stop the weld with the following procedure:

- a. Stop the forward motion of the electrode.
- b. Gradually withdraw the electrode to break the arc and leave the crater.

Job Sheet 1

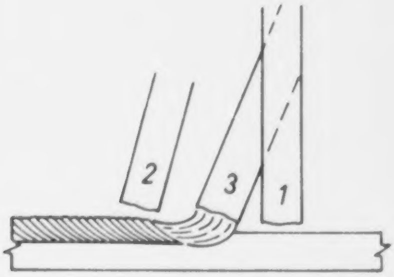
☐ 13. Chip the slag off the end of the weld about ½″ back.

Caution: Always wear safety glasses when working with a chipping hammer.

☐ 14. Restart the arc with the following procedure:

a. Restart the arc about ½″ in front of the forward end of the crater.

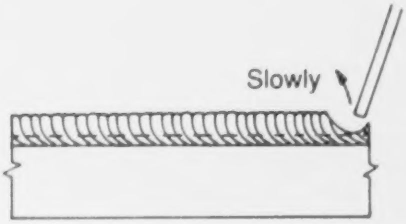
b. Move the electrode quickly to the back crown of the crater and immediately resume welding in the direction of travel.



Courtesy Lincoln Electric Company

☐ 15. Continue welding until the bead reaches the end of the plate, then crater and backfill with the following procedure:

a. Draw the electrode slowly up and slightly backward over the completed weld.



Courtesy Lincoln Electric Company

b. Make sure the motion is slow enough to allow the crater to fill and that the backward motion is far enough that the crater remains on top of the bead about ¼″ to ½″ back from the end of the weld.

Job Sheet 1

☐ 16. Take electrode from holder and place holder on hook.

☐ 17. Secure workpiece with pliers and clean the weld thoroughly with a chipping hammer and wire brush.

☐ 18. Inspect weld for bead width, undercut, spatter, poor fusion, and other irregularitites.

☐ 19. Inspect restart point.

☐ 20. Inspect crater and backfill at the edge of the weld.

☐ 21. Have your instructor check your work.

☐ 22. Take the electrode holder and reinsert the electrode or start with a new electrode.

☐ 23. Start an arc and run another bead.

☐ 24. Stop the forward motion of the electrode midpoint in the bead, allow the crater to fill, and gradually withdraw the electrode to break the arc.

☐ 25. Chip slag off crater, restart arc, and continue welding as previously outlined.

☐ 26. Continue welding toward the end of the plate, but this time, break the arc about 1″ to 2″ from the end of the plate.

☐ 27. Crater and backfill with the following procedure:

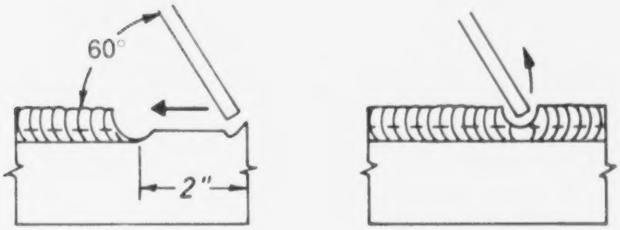
  a. Chip and remove slag from the end of bead.

  b. Move to the end of the plate, restart the arc and weld back toward the bead.

  c. Incline the electrode about 60° in the direction of travel.

Job Sheet 1

d. Weld back over the crater and stop the arc by pulling up and slightly backward as the two beads run together and the crater is properly formed on top of the bead.



Courtesy Lincoln Electric Company

☐ 28. Take electrode from holder and place holder on hook.

☐ 29. Secure workpiece with pliers and clean weld throughly with a chipping hammer and wire brush.

☐ 30. Inspect weld for bead width, undercut, spatter, poor fusion, and other irregularities.

☐ 31. Inspect restart point.

☐ 32. Inspect crater and backfill at edge of the weld.

☐ 33. Have your instructor check your work.

☐ 34. Compare the two beads you have just welded and pay special attention to the restart points and the crater and backfill techniques used to end the beads.

☐ 35. Discuss with your instructor the crater and backfill technique you felt most comfortable with.

☐ 36. Turn off machine.

☐ 37. Repeat procedure for practice as directed by your instructor.

☐ 38. Clean area and check in tools and materials or perpare for next job sheet, as directed by your instructor.

Evaluator's comments: ______________________________

____

____

Equipment, Applications, and Techniques
Unit 2

Job Sheet 2—Build a Pad on Mild Steel Plate in the Flat Position with an E6010 Electrode

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

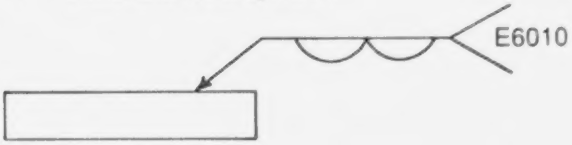
Evaluation criteria	**Rating**
Equipment setup and safety	______
First bead quality	______
Second bead quality	______
Third bead quality	______

A. Tools and materials

SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Fitter's hammer
Bench vise
Mild steel plates as selected by instructor
Welding helmet and safety glasses

B. Specifications

1. Plate and weld symbol:



2. Filler metal: E6010, 1/8" or 5/32"

3. Electrical characteristics: DC+

4. Position: Flat

Job Sheet 2

5. Direction of welding: N/A

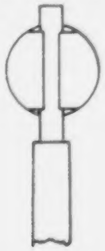
6. Cleaning: Chip and wire brush after each bead

7. Testing: Visual

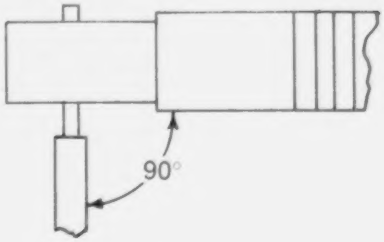
8. Technique: Whipping

C. Procedure

☐ 1. Place the electrode in the holder as indicated.



Front View



Side View

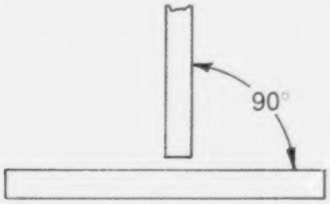
☐ 2. Place metal on worktable directly in front of you and attach ground clamp.

☐ 3. Move electrode down close to the base metal, being careful not to strike an arc, then lower your welding hood to a safe operating position.

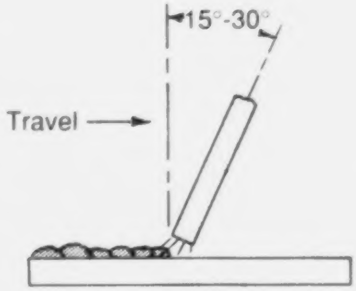
☐ 4. Start an arc by moving the electrode across the base metal at an angle about the same as used in striking a match.

☐ 5. Withdraw the electrode just as the arc is struck to form a long arc, and then lower the electrode to arc length slightly less than the diameter of your electrode.

☐ 6. Make the bead while holding the electrode perpendicular to the plate at an angle of 15° to 30° in the direction of travel while using a whipping technique.



Front View



Side View

Job Sheet 2

☐ 7. Crater and backfill at the edge of the plate.

☐ 8. Take electrode from holder and place holder on hook.

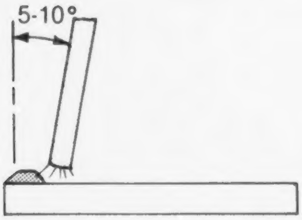
☐ 9. Secure workpiece with pliers and clean the weld thoroughly with the chipping hammer and wire brush.

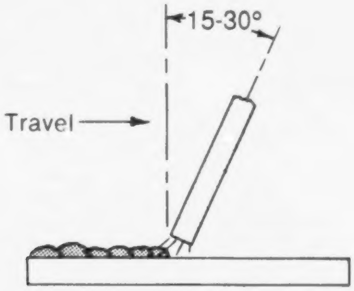
☐ 10. Inspect weld for bead width, undercut, spatter, poor fusion, and other defects.

☐ 11. Have your instructor check your work.

☐ 12. Reinsert electrode in holder and position yourself properly over the workpiece.

☐ 13. Start the second bead at the toe of the first bead so that the toe of the second bead laps to the center of the first bead and the electrode is 5° to 10° short of perpendicular.





☐ 14. Continue using the whipping technique to complete second bead so that it is the same length as the first bead, then stop, clean, and inspect.

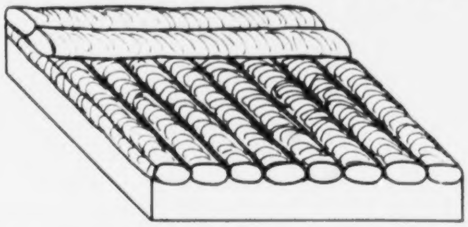
☐ 15. Continue making beads as required to cover the plate by starting at the toe of each preceding bead and keeping the electrode adjusted 5° to 10° short of perpendicular.

☐ 16. Clean each bead throughly and inspect for defects.

☐ 17. Complete first layer of beads and inspect the pad.

Job Sheet 2

☐ 18. Turn the workpiece at a 90° angle and weld the first bead on the second layer using the same whipping technique as used on the first layer.

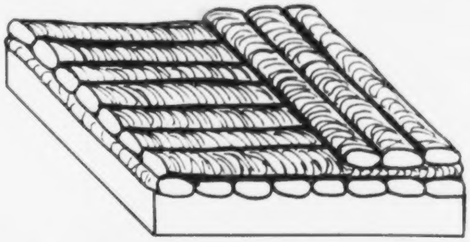


☐ 19. Clean and inspect first bead on the second layer, then continue with all beads on the second layer, being sure to adjust electrode angle and continue using the whipping technique with each bead.

☐ 20. Clean and inspect each bead.

☐ 21. Have your instructor check your completed second layer.

☐ 22. Turn the workpiece at a 90° angle and weld the first bead of the third layer the same as the first beads on layers one and two.



☐ 23. Clean and inspect the first bead of the third layer, then continue making beads to complete the third layer on the pad.

☐ 24. Adjust electrode angle as required and continue to use the whipping technique.

☐ 25. Complete, clean, and inspect third layer and have your instructor check your work.

☐ 26. Continue adding layers to the pad as directed by your instructor.

☐ 27. Stop after each layer and have your instructor check your work.

Job Sheet 2

☐ 28. Shut down equipment, clean up area, and check in tools and materials, or prepare for next job sheet as directed by your instructor.

Evaluator's comments: ____________________

____

____

Equipment, Applications, and Techniques
Unit 2

Job Sheet 3—Build a Pad on Mild Steel Plate in the Flat Position with an E7018 Electrode

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

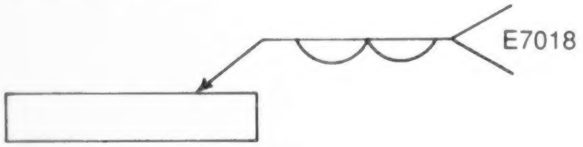
Evaluation criteria	**Rating**
Equipment setup and safety	______
First bead quality	______
Second bead quality	______
Third bead quality	______

A. Tools and materials

SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Fitter's hammer
Bench vise
Mild steel plates as selected by instructor
Welding helmet and safety giasses

B. Specifications

1. Plate and weld symbol:



2. Filler metal: E7018, ⅛″ or $\frac{5}{32}$″

3. Electrical characteristics: DC+ or AC

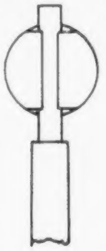
4. Position: Flat

Job Sheet 3

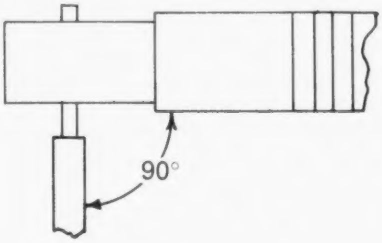
5. Direction of welding: N/A
6. Cleaning: Chip and wire brush after each bead
7. Testing: Visual
8. Technique: Drag

C. Procedure

☐ 1. Place the electrode in the holder as indicated.



Front View



Side View

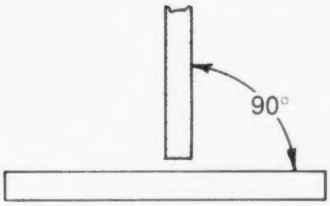
☐ 2. Place metal on worktable directly in front of you and attach ground clamp.

☐ 3. Move electrode down close to the base metal, being careful not to strike an arc, then lower your welding hood to a safe operating position.

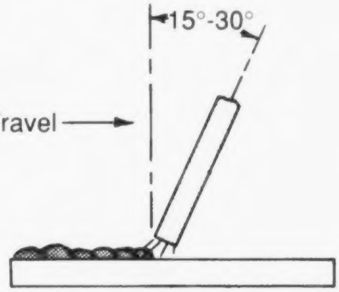
☐ 4. Start an arc by moving the electrode across the base metal at an angle about the same as used in striking a match.

☐ 5. Withdraw the electrode just as the arc is struck to form a long arc, and then lower the electrode to minimal arc length.

☐ 6. Make the bead while holding the electrode perpendicular to the plate at an angle of 5° to 30° in the direction of travel while using a drag technique.



Front View



Side View

Job Sheet 3

☐ 7. Crater and backfill at the edge of the plate.

☐ 8. Take electrode from holder and place holder on hook.

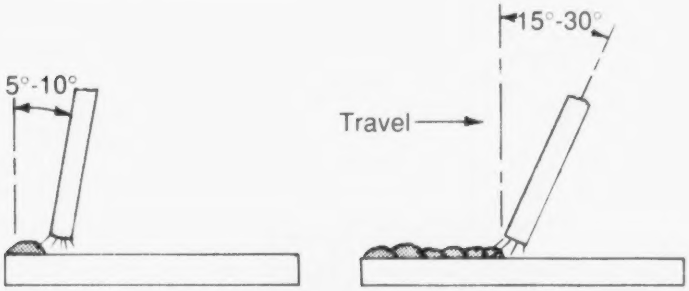
☐ 9. Secure workpiece with pliers and clean the weld thoroughly with the chipping hammer and wire brush.

☐ 10. Inspect weld for bead width, undercut, spatter, poor fusion, and other defects.

☐ 11. Have your instructor check your work.

☐ 12. Reinsert electrode in holder and position yourself properly over the workpiece.

☐ 13. Start the second bead at the toe of the first bead so that the toe of the second bead laps to the center of the first bead and the electrode is 5° to 10° short of perpendicular.



☐ 14. Continue using the drag technique to complete second bead so that it is the same length as the first bead, then stop, clean, and inspect.

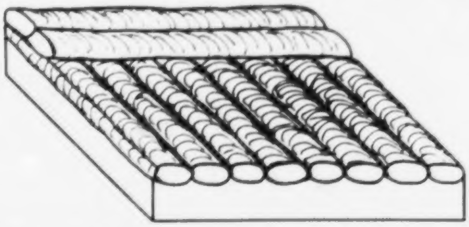
☐ 15. Continue making beads as required to cover the plate by starting at the toe of each preceding bead and keeping the electrode adjusted 5° to 10° short of perpendicular.

☐ 16. Clean each bead throughly and inspect for defects.

☐ 17. Complete first layer of beads and inspect the pad.

Job Sheet 3

☐ 18. Turn the workpiece at a 90° angle and weld the first bead on the second layer using the same drag technique as used on the first layer.

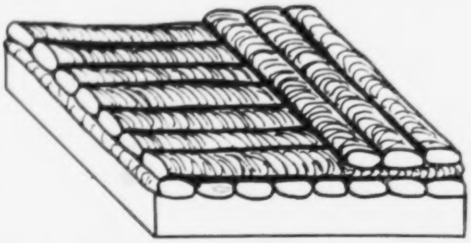


☐ 19. Clean and inspect first bead on the second layer, then continue with all beads on the second layer, being sure to adjust electrode angle and continue using the drag technique with each bead.

☐ 20. Clean and inspect each bead.

☐ 21. Have your instructor check your completed second layer.

☐ 22. Turn the workpiece at a 90° angle and weld the first bead of the third layer the same as the first beads on layers one and two.



☐ 23. Clean and inspect the first bead of the third layer, then continue making beads to complete the third layer on the pad.

☐ 24. Adjust electrode angle as required and continue to use the drag technique.

☐ 25. Complete, clean, and inspect third layer and have your instructor check your work.

☐ 26. Continue adding layers to the pad as directed by your instructor.

☐ 27. Stop after each layer and have your instructor check your work.

Job Sheet 3

☐ 28. Shut down equipment, clean up area, and check in tools and materials, or prepare for next job sheet, as directed by your instructor.

Evaluator's comments: ______________________________

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Equipment, Applications, and Techniques
Unit 2

Job Sheet 4—Weld to Specifications a Fillet Weld Lap Joint in the Flat Position with an E6010 Electrode

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

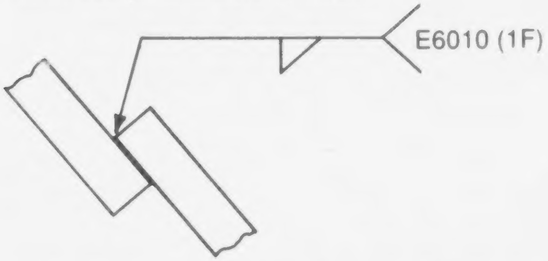
Evaluation criteria	**Rating**
Equipment setup and safety	______
First bead quality	______
Second bead quality	______
Third bead quality	______

A. Tools and materials

SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Fitter's hammer
Bench vise
Mild steel plates as selected by instructor
Welding helmet and safety glasses

B. Specifications

1. Joint design and weld symbol:



2. Filler metal and number of beads: E6010, ⅛″ or 5/32″, single pass
3. Electrical characteristics: DC+

Job Sheet 4

4. Position: 1F
5. Direction of welding: N/A
6. Cleaning: Chip and wire brush
7. Testing: Visual and break test
8. Technique: Whipping

C. Procedure

☐ 1. Attach ground clamp to table or workpiece.

☐ 2. Select correct polarity for electrode.

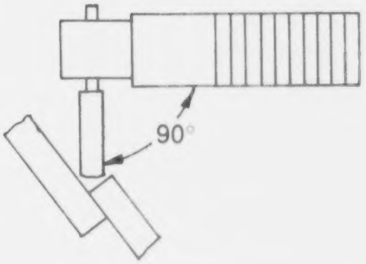
☐ 3. Turn on welding machine.

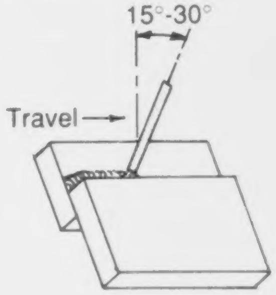
☐ 4. Adjust to correct amperage by running short beads on scrap material.

☐ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.

☐ 6. Place the joint so the weld will be in the correct position.

☐ 7. Place electrode in holder as indicated.





Front View

☐ 8. Start arc and adjust electrode to correct arc length.

☐ 9. Adjust travel speed and electrode angle as required to make correct bead shape.

☐ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.

Job Sheet 4

☐ 11. Secure the workpiece with pliers, and chip and brush the weld.

☐ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.

☐ 13. Have your instructor check your work.

☐ 14. Break test the plates by placing one plate securely in a vise and hammering on the back side of the other plate.

Note: Follow your instructor's directions for breaking the weld.

☐ 15. Inspect the bead to see if it broke down the middle as it should, and inspect for even penetration on both plates.

☐ 16. Tack weld the plates back together if requried by your instructor.

Note: The three following items are optional, depending on instructor's directions.

☐ 17. Adjust machine, electrode angle, and travel speed as required and weld other side of joint.

☐ 18. Secure workpiece with pliers, and chip and brush.

☐ 19. Inspect and test weld.

☐ 20. Have your instructor check your work.

☐ 21. Turn off machine.

☐ 22. Check in tools and materials and clean area, or prepare for next job sheet, as directed by instructor.

Evaluator's comments: ______________________________

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Equipment, Applications, and Techniques
Unit 2

Job Sheet 5—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Flat Position with an E6010 Electrode

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

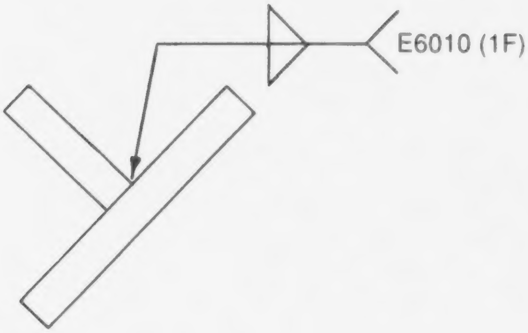
Evaluation criteria	**Rating**
Equipment setup and safety	______
First bead quality	______
Quality of other passes	______

A. Tools and materials

SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Mild steel plates as selected by instructor
Welding helmet and safety glasses

B. Specifications

1. Joint design and weld symbol:



2. Filler metal and number of beads: E6010, 1/8" or 5/32", three or more passes

3. Electrical characteristics: DC+

Job Sheet 5

4. Position: 1F

5. Direction of welding: N/A

6. Cleaning: Chip and wire brush

7. Testing: Visual

8. Technique: Whipping

C. Procedure

☐ 1. Attach ground clamp to table or workpiece.

☐ 2. Select correct polarity for electrode.

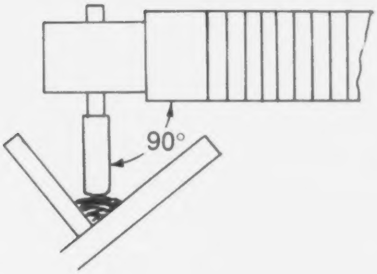
☐ 3. Turn on welding machine.

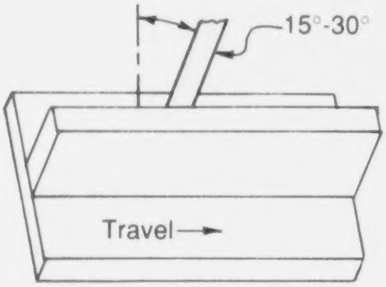
☐ 4. Adjust to correct amperage by running short beads on scrap material.

☐ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.

☐ 6. Place the joint so the weld will be in the correct position.

☐ 7. Place electrode in holder as indicated.





Front View

☐ 8. Start an arc and adjust electrode to correct arc length.

☐ 9. Adjust travel speed and electrode angle as required to make correct bead shape.

☐ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.

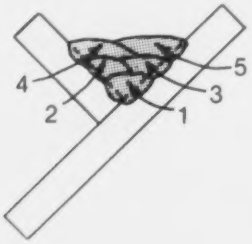
Job Sheet 5

☐ 11. Secure the workpiece with pliers, and chip and brush the weld.

☐ 12. Inspect weld visually for undercutting, too much spatter, and bead shape

☐ 13. Have your instructor check your work.

☐ 14. Weld other passes as required and be sure to clean and inspect each pass.



End View

☐ 15. Have your instructor check your work.

☐ 16. Repeat procedure for other side of joint, if requried by your instructor.

☐ 17. Have your instructor check your work.

☐ 18. Turn off machine.

☐ 19. Check in tools and materials and clean area, or prepare for next job sheet, as directed by your instructor.

Evaluator's comments: ____________________

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Equipment, Applications, and Techniques
Unit 2

Job Sheet 6—Weld to Specifications a Fillet Weld Lap Joint in the Flat Position with an E7018 Electrode

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

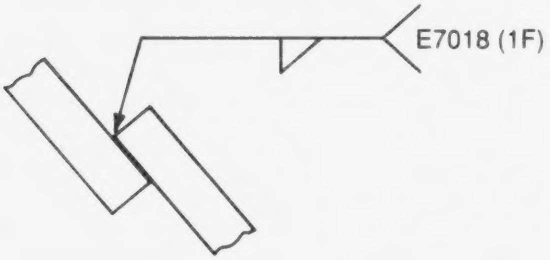
Evaluation criteria	**Rating**
Equipment setup and safety	______
First bead quality	______
Quality of other passes	______

A. Tools and materials

SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Mild steel plates as selected by instructor
Welding helmet and safety glasses

B. Specifications

1. Joint design and weld symbol:



2. Filler metal and number of beads: E7018, ⅛″ or 5⁄32″, single pass

3. Electrical characteristics: AC or DC+

4. Position: 1F

Job Sheet 6

5. Direction of welding: N/A

6. Cleaning: Chip and wire brush

7. Testing: Visual and break test

8. Technique: Drag

C. Procedure

☐ 1. Attach ground clamp to table or workpiece.

☐ 2. Select correct polarity for electrode.

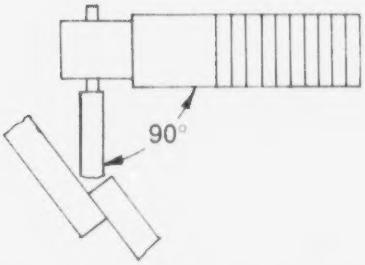
☐ 3. Turn on welding machine.

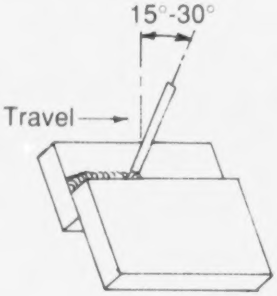
☐ 4. Adjust to correct amperage by running short beads on scrap material.

☐ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.

☐ 6. Place the joint so the weld will be in the correct position.

☐ 7. Place electrode in holder as indicated.





☐ 8. Start an arc and adjust electrode to correct arc length.

☐ 9. Adjust travel speed and electrode angle as required to make correct bead shape.

☐ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.

☐ 11. Secure the workpiece with pliers, and chip and brush the weld.

☐ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.

Job Sheet 6

☐ 13. Have your instructor check your work.

☐ 14. Break test the plates by placing one plate securely in a vise and hammering on the back side of the other plate.

☐ 15. Inspect bead to see if it breaks in the middle as it should and to make sure it has even penetration on both plates.

☐ 16. Tack weld plates back together if required by instructor.

Note: The three following items are optional depending on instructor's directions.

☐ 17. Adjust machine, electrode angle, and travel speed as required and weld other side of joint.

☐ 18. Secure workpiece with pliers, and chip and brush.

☐ 19. Inspect and test weld.

☐ 20. Have your instructor check your work.

☐ 21. Turn off machine.

☐ 22. Check in tools and materials and clean area, or prepare for next job sheet, as directed by instructor.

Evaluator's comments: ____

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Equipment, Applications, and Techniques
Unit 2

Job Sheet 7—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Flat Position with an E7018 Electrode

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

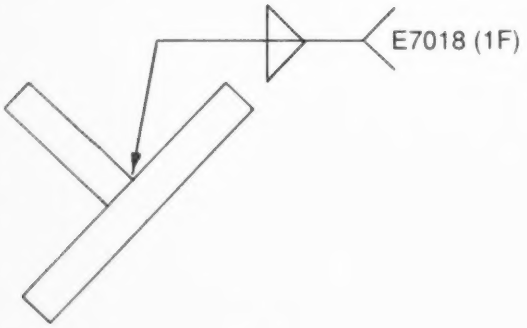
Evaluation criteria	**Rating**
Equipment setup and safety	______
First bead quality	______
Quality of other passes	______

A. Tools and materials

SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Mild steel plates as selected by instructor
Welding helmet and safety glasses

B. Specifications

1. Joint design and weld symbol:



2. Filler metal and number of beads: E7018, ⅛″ or 5⁄32″, three or more passes

3. Electrical characteristics: DC+ or AC

Job Sheet 7

4. Position: 1F

5. Direction of welding: N/A

6. Cleaning: Chip and wire brush

7. Testing: Visual

8. Technique: Drag

C. Procedure

☐ 1. Attach ground clamp to table or workpiece.

☐ 2. Select correct polarity for electrode.

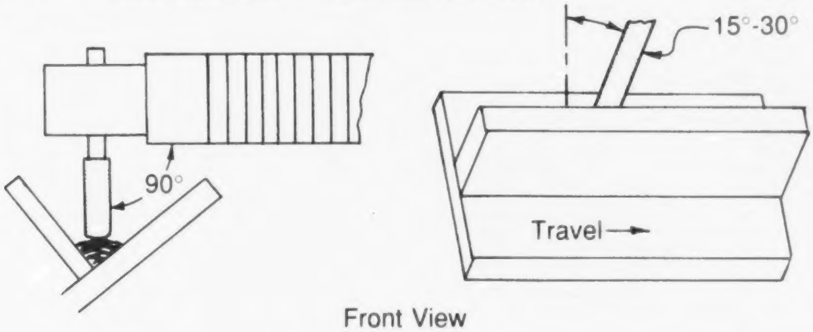
☐ 3. Turn on welding machine.

☐ 4. Adjust to correct amperage by running short beads on scrap material.

☐ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.

☐ 6. Place the joint so the weld will be in the correct position.

☐ 7. Place electrode in holder as indicated.



Front View

☐ 8. Start an arc and adjust electrode to correct arc length.

☐ 9. Adjust travel speed and electrode angle as required to make correct bead shape.

☐ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.

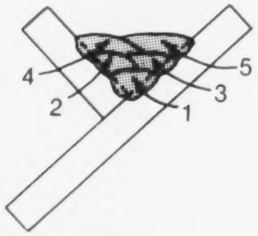
☐ 11. Secure the workpiece with pliers, and chip and brush the weld.

Job Sheet 7

☐ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.

☐ 13. Have your instructor check your work.

☐ 14. Weld other passes as required and be sure to clean and inspect each pass.



Front View

☐ 15. Have your instructor check your work.

☐ 16. Repeat procedure for other side of joint, if requried by your instructor.

☐ 17. Clean and inspect all passes.

☐ 18. Have your instructor check your work.

☐ 19. Turn off machine.

☐ 20. Check in tools and materials and clean area, or prepare for next job sheet, as directed by instructor.

Evaluator's comments: ______________________________

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Equipment, Applications, and Techniques
Unit 2

Job Sheet 8—Weld to Specifications a Fillet Weld Lap Joint in the Flat Position with an E7024 Electrode

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

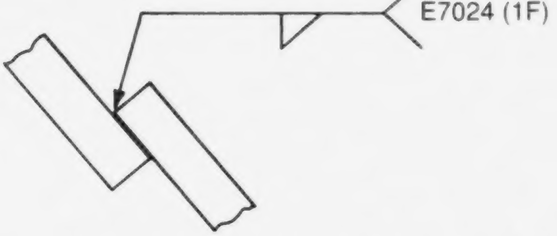
Evaluation criteria	**Rating**
Equipment setup and safety	______
First bead quality	______
Bead quality after break	______
Quality of other beads	______

A. Tools and materials

SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Fitter's hammer
Bench vise
Mild steel plates as selected by instructor
Welding helmet and safety glasses

B. Specifications

1. Joint design and weld symbol:



2. Filler metal and number of beads: E7024, ⅛″ or 5⁄32″, single pass

3. Electrical characteristics: AC, DC+, or DC−

Job Sheet 8

4. Position: 1F
5. Direction of welding: N/A
6. Cleaning: Chip and wire brush
7. Testing: Visual and break test
8. Technique: Drag

C. Procedure

☐ 1. Attach ground clamp to table or workpiece.

☐ 2. Select correct polarity for electrode.

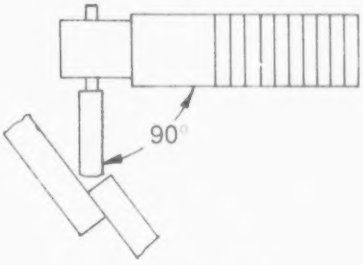
☐ 3. Turn on welding machine.

☐ 4. Adjust to correct amperage by running short beads on scrap material.

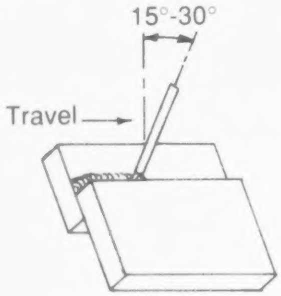
☐ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.

☐ 6. Place the joint so the weld will be in the correct position.

☐ 7. Place electrode in holder as indicated.



Front View



☐ 8. Start an arc and adjust electrode to correct arc length.

☐ 9. Adjust travel speed and electrode angle as required to make correct bead shape.

☐ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.

☐ 11. Secure the workpiece with pliers, and chip and brush the weld.

Job Sheet 8

☐ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.

☐ 13. Have your instructor check your work.

☐ 14. Break test the plates by placing one plate securely in a vise and hammering on the back side of the other plate.

☐ 15. Inspect bead to see if it breaks in the middle as it should and to make sure it has even penetration on both plates.

☐ 16. Tack weld plates back together, if required by instructor.

Note: The following three items are optional, depending on your instructor's directions.

☐ 17. Adjust machine, electrode angle, and travel speed as required and weld other side of joint.

☐ 18. Secure workpiece with pliers, and chip and brush.

☐ 19. Inspect and test weld.

☐ 20. Have your instructor check your work.

☐ 21. Turn off machine.

☐ 22. Check in tools and materials and clean area, or prepare for next job sheet, as directed by instructor.

Evaluator's comments: ______________________________

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Equipment, Applications, and Techniques
Unit 2

Job Sheet 9—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Flat Position with an E7024 Electrode

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

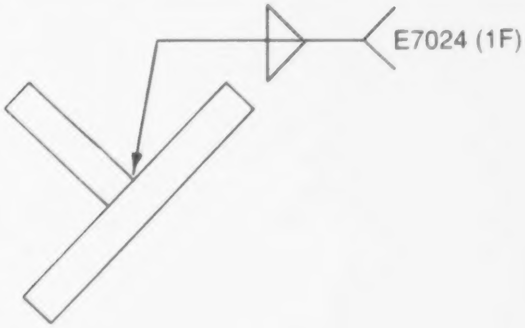
Evaluation criteria	**Rating**
Equipment setup and safety	______
First bead quality	______
Quality of other passes	______

A. Tools and materials

SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Mild steel plates as selected by instructor
Welding helmet and safety glasses

B. Specifications

1. Joint design and weld symbol:



2. Filler metal and number of beads: E7024, $\frac{1}{8}$" or $\frac{5}{32}$", three or more passes

3. Electrical characteristics: DC+, DC−, or AC

Job Sheet 9

4. Position: 1F
5. Direction of welding: N/A
6. Cleaning: Chip and wire brush
7. Testing: Visual
8. Technique: Drag

C. Procedure

☐ 1. Attach ground clamp to table or workpiece.

☐ 2. Select correct polarity for electrode.

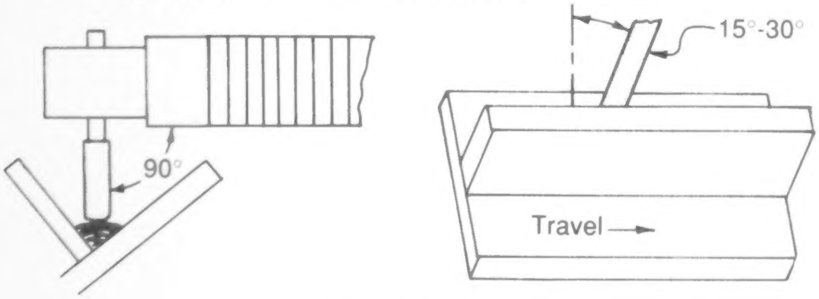
☐ 3. Turn on welding machine.

☐ 4. Adjust to correct amperage by running short beads on scrap material.

☐ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.

☐ 6. Place the joint so the weld will be in the correct position.

☐ 7. Place electrode in holder as indicated.



Front View

☐ 8. Start an arc and adjust electrode to correct arc length.

☐ 9. Adjust travel speed and electrode angle as required to make correct bead shape.

☐ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.

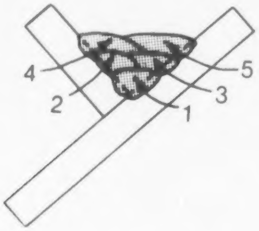
☐ 11. Secure the workpiece with pliers, and chip and brush the weld.

Job Sheet 9

☐ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.

☐ 13. Have your instructor check your work.

☐ 14. Weld other passes as required and be sure to clean and inspect each pass.



End View

☐ 15. Have your instructor check your work.

☐ 16. Repeat procedrue for other side of joint, if required by your instructor.

☐ 17. Clean and inspect all passes.

☐ 18. Have your instructor check your work.

☐ 19. Turn off machine.

☐ 20. Check in tools and materials and clean area, or prepare for next job sheet, as directed by instructor.

Evaluator's comments: ____

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Equipment, Applications, and Techniques
Unit 2

Job Sheet 10—Weld to Specifications a Fillet Weld Lap Joint in the Horizontal Position with an E6010 Electrode

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

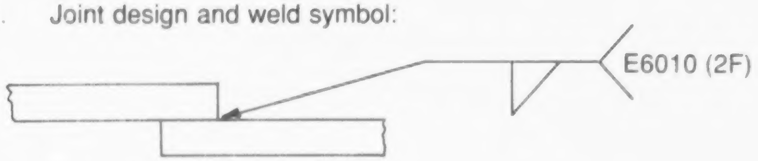
Evaluation criteria	**Rating**
Equipment setup and safety	______
First bead quality	______
Quality after break test	______
Quality of other beads	______

A. Tools and materials

SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Fitter's hammer
Bench vise
Mild steel plates as selected by instructor
Welding helmet and safety glasses

B. Specifications

1. Joint design and weld symbol:



2. Filler metal and number of beads: E6010, ⅛″ or ⁵⁄₃₂″, single pass

3. Electrical characteristics: DC+

4. Position: 2F

Job Sheet 10

5. Direction of welding: N/A

6. Cleaning: Chip and wire brush

7. Testing: Visual and break test

8. Technique: Whipping

C. Procedure

☐ 1. Attach ground clamp to table or workpiece.

☐ 2. Select correct polarity for electrode.

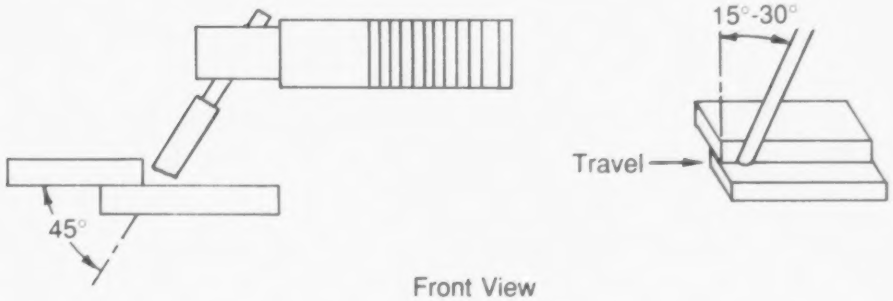
☐ 3. Turn on welding machine.

☐ 4. Adjust to correct amperage by running short beads on scrap material.

☐ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.

☐ 6. Place the joint so the weld will be in the correct position.

☐ 7. Place electrode in holder as indicated.



Front View

☐ 8. Start an arc and adjust electrode to correct arc length.

☐ 9. Adjust travel speed and electrode angle as required to make correct bead shape.

☐ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.

☐ 11. Secure the workpiece with pliers, and chip and brush the weld.

☐ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.

Job Sheet 10

☐ 13. Have your instructor check your work.

☐ 14. Break test the plates by placing one plate securely in a vise and hammering on the back side of the other plate.

☐ 15. Inspect bead to see if it breaks in the middle as it should and to make sure it has even penetration on both plates.

☐ 16. Tack weld plates back together, if required by instructor.

Note: The following three items are optional, depending on your instructor's directions.

☐ 17. Adjust machine, electrode angle, and travel speed as required and weld other side of joint.

☐ 18. Secure workpiece with pliers, and chip and brush.

☐ 19. Inspect and test weld.

☐ 20. Have your instructor check your work.

☐ 21. Turn off machine.

☐ 22. Check in tools and materials and clean area, or prepare for next job sheet, as directed by instructor.

Evaluator's comments: ____

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Equipment, Applications, and Techniques
Unit 2

Job Sheet 11—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Horizontal Position with an E6010 Electrode

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

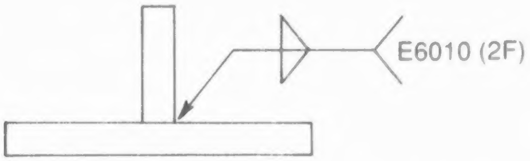
Evaluation criteria	**Rating**
Equipment setup and safety	______
First bead quality	______
Quality of other passes	______

A. Tools and materials

SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Mild steel plates as selected by instructor
Welding helmet and safety glasses

B. Specifications

1. Joint design and weld symbol:



2. Filler metal and number of beads: E6010, 1/8" or 5/32", three or more passes

3. Electrical characteristics: DC+

4. Position: 2F

5. Direction of welding: N/A

6. Cleaning: Chip and wire brush

Job Sheet 11

7. Testing: Visual

8. Technique: Whipping

C. Procedure

☐ 1. Attach ground clamp to table or workpiece.

☐ 2. Select correct polarity for electrode.

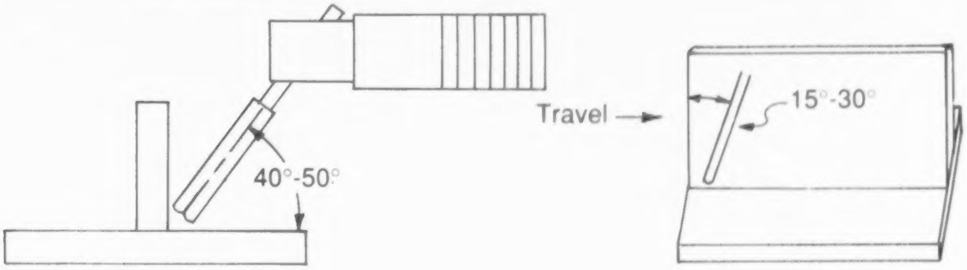
☐ 3. Turn on welding machine.

☐ 4. Adjust to correct amperage by running short beads on scrap material.

☐ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.

☐ 6. Place the joint so the weld will be in the correct position.

☐ 7. Place electrode in holder as indicated.



Front View

☐ 8. Start an arc and adjust electrode to correct arc length.

☐ 9. Adjust travel speed and electrode angle as required to make correct bead shape.

☐ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.

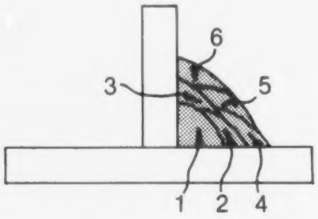
☐ 11. Secure the workpiece with pliers, and chip and brush the weld.

☐ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.

☐ 13. Have your instructor check your work.

Job Sheet 11

☐ 14. Weld other passes as required and be sure to clean and inspect each pass.



End View

☐ 15. Have your instructor check your work.

☐ 16. Repeat procedure for other side of joint, if required by your instructor.

☐ 17. Clean and inspect all passes.

☐ 18. Have your instructor check your work.

☐ 19. Turn off machine.

☐ 20. Check in tools and materials and clean area, or prepare for next job sheet, as directed by instructor.

Evaluator's comments: ______________________________

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Equipment, Applications, and Techniques
Unit 2

Job Sheet 12—Weld to Specifications a Fillet Weld Lap Joint in the Horizontal Position with an E7018 Electrode

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

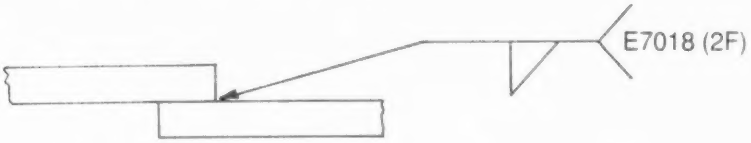
Evaluation criteria	**Rating**
Equipment setup and safety	______
First bead quality	______
Quality after break test	______
Bead on other side	______

A. Tools and materials

SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Fitter's hammer
Bench vise
Mild steel plates as selected by instructor
Welding helmet and safety glasses

B. Specifications

1. Joint design and weld symbol:



2. Filler metal and number of beads: E7018, ⅛″ or ⁵⁄₃₂″, single pass
3. Electrical characteristics: AC or DC+
4. Position: 2F

Job Sheet 12

5. Direction of welding: N/A
6. Cleaning: Chip and wire brush
7. Testing: Visual and break test
8. Technique: Drag

C. Procedure

☐ 1. Attach ground clamp to table or workpiece.

☐ 2. Select correct polarity for electrode.

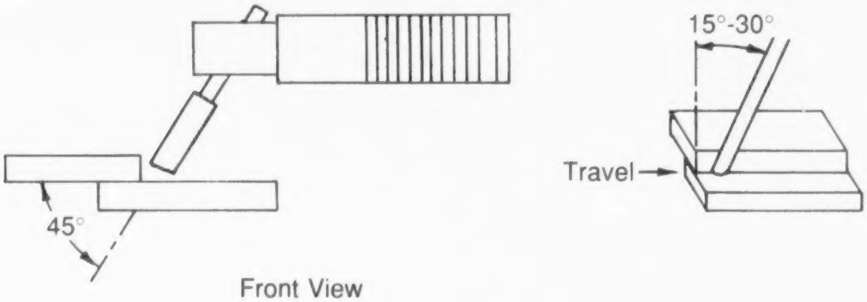
☐ 3. Turn on welding machine.

☐ 4. Adjust to correct amperage by running short beads on scrap material.

☐ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.

☐ 6. Place the joint so the weld will be in the correct position.

☐ 7. Place electrode in holder as indicated.



Front View

☐ 8. Start an arc and adjust electrode to correct arc length.

☐ 9. Adjust travel speed and electrode angle as required to make correct bead shape.

☐ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.

☐ 11. Secure the workpiece with pliers, and chip and brush the weld.

☐ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.

Job Sheet 12

☐ 13. Have your instructor check your work.

☐ 14. Break test the plates by placing one plate securely in a vise and hammering on the back side of the other plate.

☐ 15. Inspect bead to see if it breaks in the middle as it should and to make sure it has even penetration on both plates.

☐ 16. Tack weld plates back together, if required by instructor.

Note: The following three items are optional, depending on your instructor's directions.

☐ 17. Adjust machine, electrode angle, and travel speed as required and weld other side of joint.

☐ 18. Secure workpiece with pliers, and chip and brush.

☐ 19. Inspect and test weld.

☐ 20. Have your instructor check your work.

☐ 21. Turn off machine.

☐ 22. Check in tools and materials and clean area, or prepare for next job sheet, as directed by instructor.

Evaluator's comments: ____________________

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Equipment, Applications, and Techniques
Unit 2

Job Sheet 13—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Horizontal Position with an E7018 Electrode

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

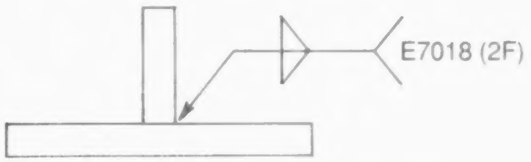
Evaluation criteria	**Rating**
Equipment setup and safety	______
First bead quality	______
Quality of other passes	______

A. Tools and materials

SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Mild steel plates as selected by instructor
Welding helmet and safety glasses

B. Specifications

1. Joint design and weld symbol:



2. Filler metal and number of beads: E7018, ⅛″ or 5/32″, three or more passes
3. Electrical characteristics: DC+ or AC
4. Position: 2F
5. Direction of welding: N/A
6. Cleaning: Chip and wire brush

Job Sheet 13

7. Testing: Visual

8. Technique: Drag

C. Procedure

☐ 1. Attach ground clamp to table or workpiece.

☐ 2. Select correct polarity for electrode.

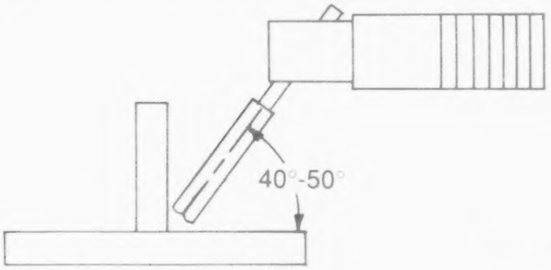
☐ 3. Turn on welding machine.

☐ 4. Adjust to correct amperage by running short beads on scrap material.

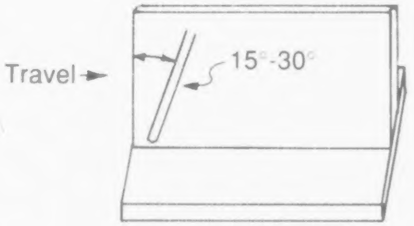
☐ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.

☐ 6. Place the joint so the weld will be in the correct position.

☐ 7. Place electrode in holder as indicated.



Front View



☐ 8. Start an arc and adjust electrode to correct arc length.

☐ 9. Adjust travel speed and electrode angle as required to make correct bead shape.

☐ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.

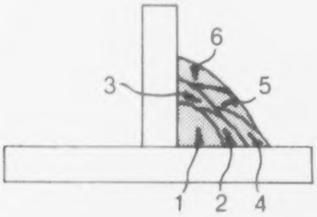
☐ 11. Secure the workpiece with pliers, and chip and brush the weld.

☐ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.

☐ 13. Have your instructor check your work.

Job Sheet 13

☐ 14. Weld other passes as required and be sure to clean and inspect each pass.



Front View

☐ 15. Have your instructor check your work.

☐ 16. Repeat procedure for other side of joint, if required by your instructor.

☐ 17. Clean and inspect all passes.

☐ 18. Have your instructor check your work.

☐ 19. Turn off machine.

☐ 20. Check in tools and materials and clean area, or prepare for next job sheet, as directed by instructor.

Evaluator's comments: ____________________

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Equipment, Applications, and Techniques
Unit 2

Job Sheet 14—Weld to Specifications a Fillet Weld Lap Joint in the Horizontal Position with an E7024 Electrode

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

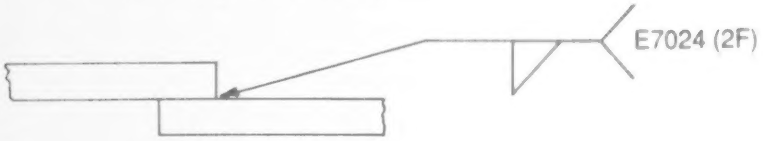
Evaluation criteria	**Rating**
Equipment setup and safety	______
First bead quality	______
Bead quality after break test	______
Bead on other side	______

A. Tools and materials

SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Fitter's hammer
Bench vise
Mild steel plates as selected by instructor
Welding helmet and safety glasses

B. Specifications

1. Joint design and weld symbol:



2. Filler metal and number of beads: E7024, ⅛″ or ⁵⁄₃₂″, single pass
3. Electrical characteristics: DC+, DC−, or AC
4. Position: 2F

Job Sheet 14

5. Direction of welding: N/A

6. Cleaning: Chip and wire brush

7. Testing: Visual and break test

8. Technique: Drag

C. Procedure

☐ 1. Attach ground clamp to table or workpiece.

☐ 2. Select correct polarity for electrode.

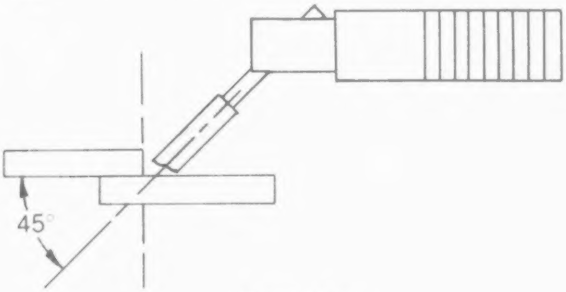
☐ 3. Turn on welding machine.

☐ 4. Adjust to correct amperage by running short beads on scrap material.

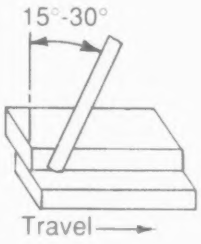
☐ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.

☐ 6. Place the joint so the weld will be in the correct position.

☐ 7. Place electrode in holder as indicated.



Front View



☐ 8. Start an arc and adjust electrode to correct arc length.

☐ 9. Adjust travel speed and electrode angle as required to make correct bead shape.

☐ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.

☐ 11. Secure the workpiece with pliers, and chip and brush the weld.

☐ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.

Job Sheet 14

☐ 13. Have your instructor check your work.

☐ 14. Break test the plates by placing one plate securely in a vise and hammering on the back side of the other plate.

☐ 15. Inspect bead to see if it breaks in the middle as it should and to make sure it has even penetration on both plates.

☐ 16. Tack weld plates back together, if required by instructor.

☐ 17. Adjust machine, electrode angle, and travel speed as required and weld other side of joint.

☐ 18. Secure workpiece with pliers, and chip and brush.

☐ 19. Inspect and test weld.

☐ 20. Have your instructor check your work.

☐ 21. Turn off machine.

☐ 22. Check in tools and materials and clean area, or prepare for next job sheet, as directed by instructor.

Evaluator's comments: ______________________________

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Equipment, Applications, and Techniques
Unit 2

Job Sheet 15—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Horizontal Position with an E7024 Electrode

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

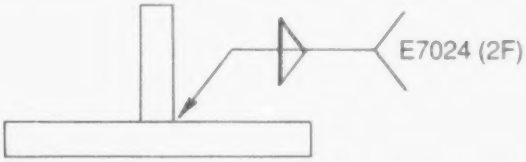
Evaluation criteria	**Rating**
Equipment setup and safety	______
First bead quality	______
Quality of other beads	______

A. Tools and materials

SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Mild steel plates as selected by instructor
Welding helmet and safety glasses

B. Specifications

1. Joint design and weld symbol:



2. Filler metal and number of beads: E7024, 1/8″ or 5/32″, three passes
3. Electrical characteristics: DC+, DC–, or AC
4. Position: 2F
5. Direction of welding: N/A
6. Cleaning: Chip and wire brush

Job Sheet 15

7. Testing: Visual

8. Technique: Drag

C. Procedure

☐ 1. Attach ground clamp to table or workpiece.

☐ 2. Select correct polarity for electrode.

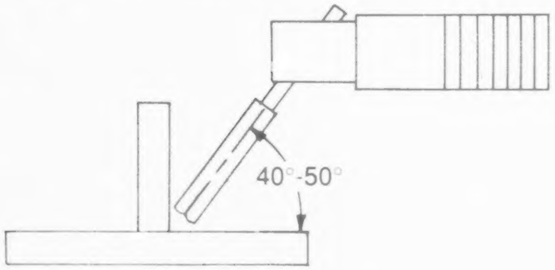
☐ 3. Turn on welding machine.

☐ 4. Adjust to correct amperage by running short beads on scrap material.

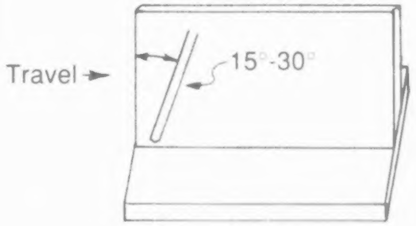
☐ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.

☐ 6. Place the joint so the weld will be in the correct position.

☐ 7. Place electrode in holder as indicated.



Front View



☐ 8. Start an arc and adjust electrode to correct arc length.

☐ 9. Adjust travel speed and electrode angle as required to make correct bead shape.

☐ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.

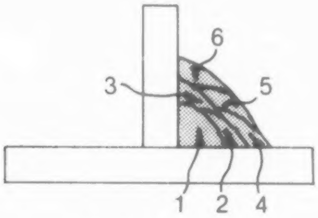
☐ 11. Secure the workpiece with pliers, and chip and brush the weld.

☐ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.

☐ 13. Have your instructor check your work.

Job Sheet 15

☐ 14. Weld other passes as required and be sure to clean and inspect each pass.



End View

☐ 15. Have your instructor check your work.

☐ 16. Repeat procedure for other side of joint, if required by your instructor.

☐ 17. Clean and inspect all passes.

☐ 18. Have your instructor check your work.

☐ 19. Turn off machine.

☐ 20. Check in tools and materials and clean area, or prepare for next job sheet, as directed by instructor.

Evaluator's comments: ______________________________

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Equipment, Applications, and Techniques
Unit 2

Job Sheet 16—Weld to Specifications a Fillet Weld Lap Joint in the Vertical Position with an E6010 Electrode

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

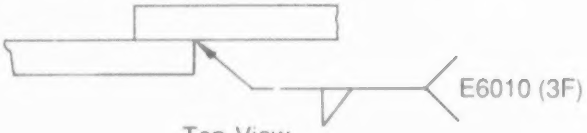
Evaluation criteria	Rating
Equipment setup and safety	______
First bead quality	______
Bead quality after break test	______
Quality of other beads	______

A. Tools and materials

SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Fitter's hammer
Bench vise
Mild steel plates as selected by instructor
Welding helmet and safety glasses

B Specifications

1. Joint design and weld symbol:



Top View

2. Filler metal and number of beads: E6010, $\frac{1}{8}$″ or $\frac{5}{32}$″, single pass
3. Electrical characteristics: DC+
4. Position: 3F

Job Sheet 16

5. Direction of welding: Vertical up
6. Cleaning: Chip and wire brush
7. Testing: Visual and break test
8. Technique: Whipping

C. Procedure

☐ 1. Attach ground clamp to table or workpiece.

☐ 2. Select correct polarity for electrode.

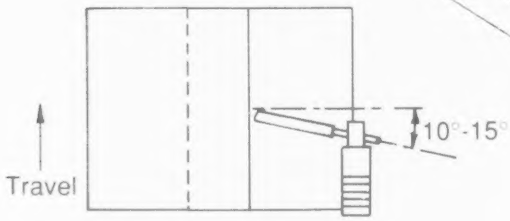
☐ 3. Turn on welding machine.

☐ 4. Adjust to correct amperage by running short beads on scrap material.

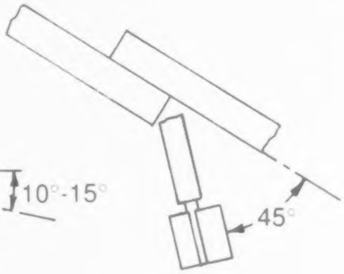
☐ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.

☐ 6. Place the joint so the weld will be in the correct position.

☐ 7. Place electrode in holder as indicated.



Front View



Top View

☐ 8. Start an arc and adjust electrode to correct arc length.

☐ 9. Adjust travel speed and electrode angle as required to make correct bead shape.

☐ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.

☐ 11. Secure the workpiece with pliers, and chip and brush the weld.

☐ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.

Job Sheet 16

☐ 13. Have your instructor check your work.

☐ 14. Break test the plates by placing one plate securely in a vise and hammering on the back side of the other plate.

☐ 15. Inspect bead to see if it breaks in the middle as it should and to make sure it has even penetration on both plates.

☐ 16. Tack weld plates back together, if required by instructor.

Note: The following three items are optional, depending on your instructor's directions.

☐ 17. Adjust machine, electrode angle, and travel speed as required and weld other side of joint.

☐ 18. Secure workpiece with pliers, and chip and brush.

☐ 19. Inspect and test weld.

☐ 20. Have your instructor check your work.

☐ 21. Turn off machine.

☐ 22. Check in tools and materials and clean area, or prepare for next job sheet, as directed by instructor.

Evaluator's comments: ______________________________

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Equipment, Applications, and Techniques
Unit 2

Job Sheet 17—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Vertical Position with an E6010 Electrode

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

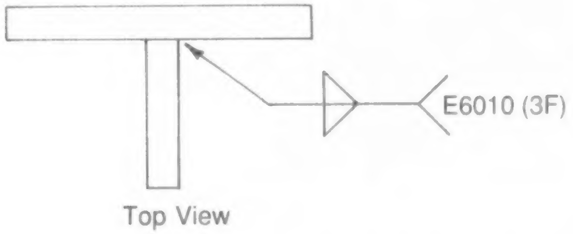
Evaluation criteria	**Rating**
Equipment setup and safety	______
First bead quality	______
Quality of other beads	______

A. Tools and materials

SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Mild steel plates as selected by instructor
Welding helmet and safety glasses

B. Specifications

1. Joint design and weld symbol:



2. Filler metal and number of beads: E6010, $\frac{1}{8}$″ or $\frac{5}{32}$″, three passes
3. Electrical characteristics: DC+
4. Position: 3F
5. Direction of welding: Vertical up

Job Sheet 17

6. Cleaning: Chip and wire brush
7. Testing: Visual
8. Technique: Whipping

C. Procedure

☐ 1. Attach ground clamp to table or workpiece.

☐ 2. Select correct polarity for electrode.

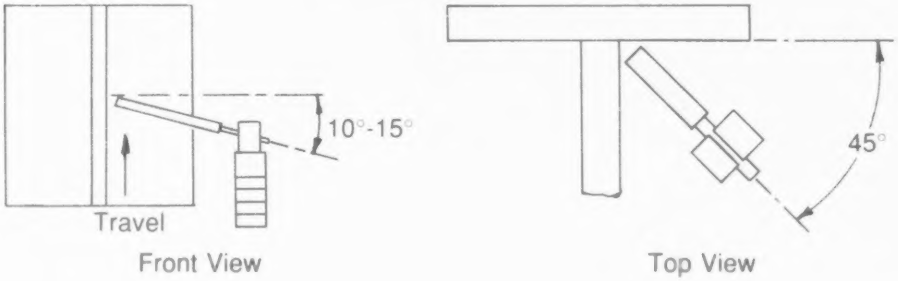
☐ 3. Turn on welding machine.

☐ 4. Adjust to correct amperage by running short beads on scrap material.

☐ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.

☐ 6. Place the joint so the weld will be in the correct position.

☐ 7. Place electrode in holder as indicated.



☐ 8. Start an arc and adjust electrode to correct arc length.

☐ 9. Adjust travel speed and electrode angle as required to make correct bead shape.

☐ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.

☐ 11. Secure the workpiece with pliers, and chip and brush the weld.

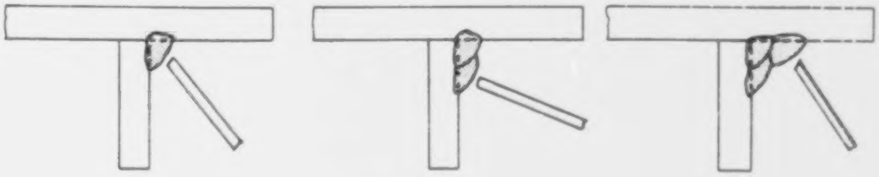
☐ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.

☐ 13. Have your instructor check your work.

Job Sheet 17

☐ 14. Weld other passes as required and be sure to clean and inspect each pass.

Top View



First Pass
Rod Angle

Second Pass
Rod Angle

Third Pass
Rod Angle

☐ 15. Have your instructor check your work.

☐ 16. Repeat the procedure for welding the other side of the joint, if required by your instructor.

☐ 17. Clean and inspect all passes.

☐ 18. Have your instructor check your work.

☐ 19. Turn off machine.

☐ 20. Check in tools and materials and clean area, or prepare for next job sheet, as directed by instructor.

Evaluator's comments: ______________________________

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Equipment, Applications, and Techniques
Unit 2

Job Sheet 18—Weld to Specifications a Fillet Weld Lap Joint in the Vertical Position with an E7018 Electrode

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

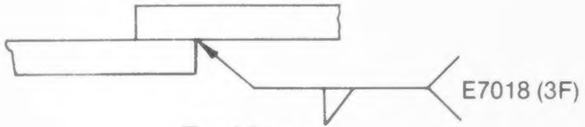
Evaluation criteria	**Rating**
Equipment setup and safety	______
First bead quality	______
Bead quality after break test	______
Quality of other beads	______

A. Tools and materials

SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Fitter's hammer
Bench vise
Mild steel plates as selected by instructor
Welding helmet and safety glasses

B. Specifications

1. Joint design and weld symbol:



Top View

2. Filler metal and number of beads: E7018, 1/8" or 5/32", single pass

3. Electrical characteristics: AC or DC+

4. Position: 3F

Job Sheet 18

5. Direction of welding: Vertical up

6. Cleaning: Chip and wire brush

7. Testing: Visual and break test

8. Technique: Drag

C. Procedure

☐ 1. Attach ground clamp to table or workpiece.

☐ 2. Select correct polarity for electrode.

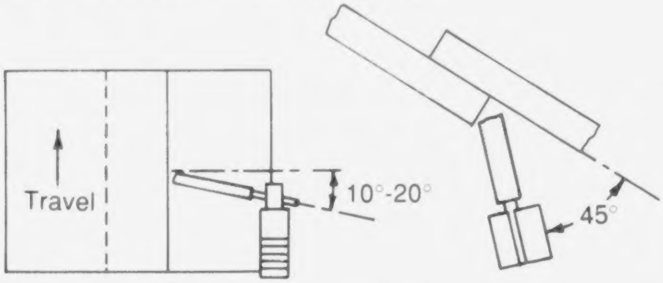
☐ 3. Turn on welding machine.

☐ 4. Adjust to correct amperage by running short beads on scrap material.

☐ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.

☐ 6. Place the joint so the weld will be in the correct position.

☐ 7. Place electrode in holder as indicated.



Front View Top View

☐ 8. Start an arc and adjust electrode to correct arc length.

☐ 9. Adjust travel speed and electrode angle as required to make correct bead shape.

☐ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.

☐ 11. Secure the workpiece with pliers, and chip and brush the weld.

☐ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.

Job Sheet 18

☐ 13. Have your instructor check your work.

☐ 14. Break test the plates by placing one plate securely in a vise and hammering on the back side of the other plate.

☐ 15. Inspect bead to see if it breaks in the middle as it should and to make sure it has even penetration on both plates.

☐ 16. Tack weld plates back together, if required by instructor.

Note: The following three items are optional, depending on your instructor's directions.

☐ 17. Adjust machine, electrode angle, and travel speed as required and weld other side of joint.

☐ 18. Secure workpiece with pliers, and chip and brush.

☐ 19. Inspect and test weld.

☐ 20. Have your instructor check your work.

☐ 21. Turn off machine.

☐ 22. Check in tools and materials and clean area, or prepare for next job sheet, as directed by instructor.

Evaluator's comments: ____

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Equipment, Applications, and Techniques
Unit 2

Job Sheet 19—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Vertical Position with an E7018 Electrode

Name ______________________ Attempt Number ______

Date ______________________ Overall Rating ______

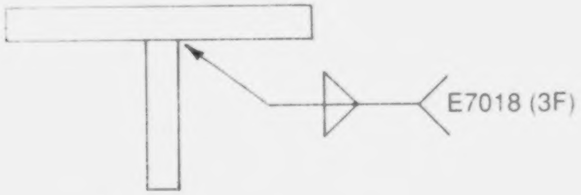
Evaluation criteria	Rating
Equipment setup and safety	____
First bead quality	____
Quality of other beads	____

A. Tools and materials

SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Mild steel plates as selected by instructor
Welding helmet and safety glasses

B. Specifications

1. Joint design and weld symbol:



Top View

2. Filler metal and number of beads: E7018, ⅛″ or 5⁄32″, three passes
3. Electrical characteristics: DC+ or AC
4. Position: 3F
5. Direction of welding: Vertical up

Job Sheet 19

6. Cleaning: Chip and wire brush

7. Testing: Visual

8. Technique: Drag

C. Procedure

☐ 1. Attach ground clamp to table or workpiece.

☐ 2. Select correct polarity for electrode.

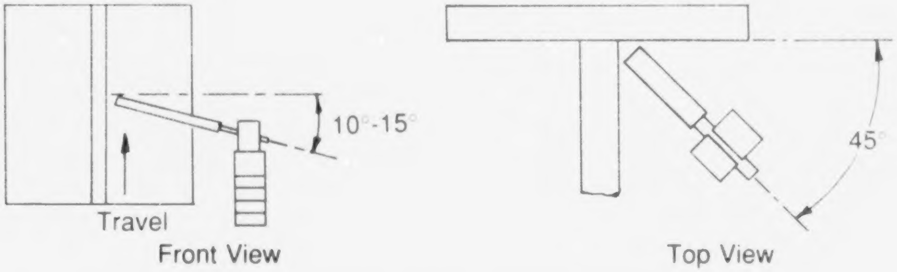
☐ 3. Turn on welding machine.

☐ 4. Adjust to correct amperage by running short beads on scrap material.

☐ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.

☐ 6. Place the joint so the weld will be in the correct position.

☐ 7. Place electrode in holder as indicated.



☐ 8. Start an arc and adjust electrode to correct arc length.

☐ 9. Adjust travel speed and electrode angle as required to make correct bead shape.

☐ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.

☐ 11. Secure the workpiece with pliers, and chip and brush the weld.

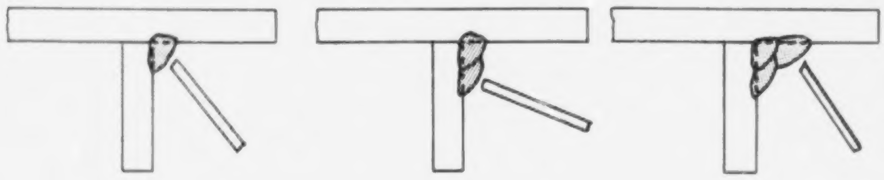
☐ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.

☐ 13. Have your instructor check your work.

Job Sheet 19

☐ 14. Weld other passes as required and be sure to clean and inspect each pass.

Top View



First Pass Rod Angle

Second Pass Rod Angle

Third Pass Rod Angle

☐ 15. Have your instructor check your work.

☐ 16. Repeat procedure for other side of joint, if required by your instructor.

☐ 17. Clean and inspect all passes.

☐ 18. Have your instructor check your work.

☐ 19. Turn off machine.

☐ 20. Check in tools and materials and clean area, or prepare for next job sheet, as directed by instructor.

Evaluator's comments: ____

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Equipment, Applications, and Techniques
Unit 2

Job Sheet 20—Weld to Specifications a Fillet Weld Lap Joint in the Overhead Position with an E6010 Electrode

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

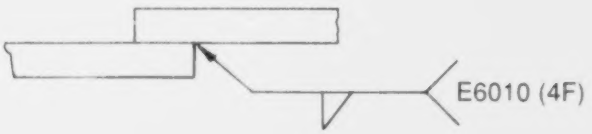
Evaluation criteria	Rating
Equipment setup and safety	____
First bead quality	____
Bead quality after break test	____
Quality of other beads	____

A. Tools and materials

SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Fitter's hammer
Bench vise
Mild steel plates as selected by instructor
Welding helmet and safety glasses

B. Specifications

1. Joint design and weld symbol:



2. Filler metal and number of beads: E6010, ⅛″ or 5/32″, single pass

3. Electrical characteristics: DC+

4. Position: 4F

Job Sheet 20

5. Direction of welding: N/A

6. Cleaning: Chip and wire brush

7. Testing: Visual and break test

8. Technique: Whipping

C. Procedure

☐ 1. Attach ground clamp to table or workpiece.

☐ 2. Select correct polarity for electrode.

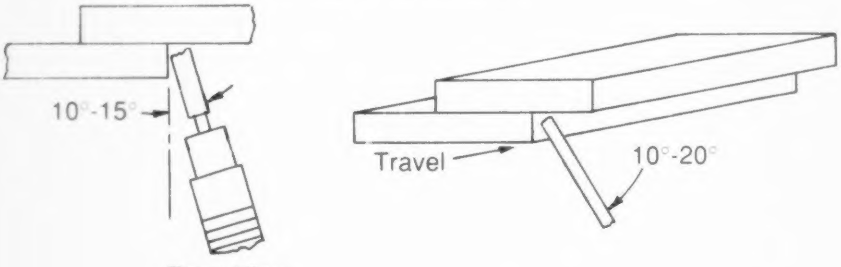
☐ 3. Turn on welding machine.

☐ 4. Adjust to correct amperage by running short beads on scrap material.

☐ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.

☐ 6. Place the joint so the weld will be in the correct position.

☐ 7. Place electrode in holder as indicated.



Front View

☐ 8. Start an arc and adjust electrode to correct arc length.

☐ 9. Adjust travel speed and electrode angle as required to make correct bead shape.

☐ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.

☐ 11. Secure the workpiece with pliers, and chip and brush the weld.

☐ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.

Job Sheet 20

☐ 13. Have your instructor check your work.

☐ 14. Break test the plates by placing one plate securely in a vise and hammering on the back side of the other plate.

☐ 15. Inspect bead to see if it breaks in the middle as it should and to make sure it has even penetration on both plates.

☐ 16. Tack weld plates back together, if required by instructor.

Note: The following three items are optional, depending on your instructor's directions.

☐ 17. Adjust machine, electrode angle, and travel speed as required and weld other side of joint.

☐ 18. Secure workpiece with pliers, and chip and brush.

☐ 19. Inspect and test weld.

☐ 20. Have your instructor check your work.

☐ 21. Turn off machine.

☐ 22. Check in tools and materials and clean area, or prepare for next job sheet, as directed by instructor.

Evaluator's comments: ____

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Equipment, Applications, and Techniques
Unit 2

Job Sheet 21—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Overhead Position with an E6010 Electrode

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

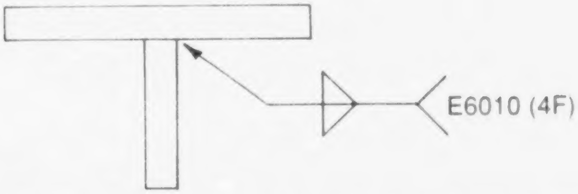
Evaluation criteria	**Rating**
Equipment setup and safety	______
First bead quality	______
Quality of other beads	______

A. Tools and materials

SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Mild steel plates as selected by instructor
Welding helmet and safety glasses

B. Specifications

1. Joint design and weld symbol:



2. Filler metal and number of beads: E6010, ⅛″ or 5⁄32″, three passes

3. Electrical characteristics: DC+

4. Position: 4F

5. Direction of welding: N/A

Job Sheet 21

6. Cleaning: Chip and wire brush

7. Testing: Visual

8. Technique: Whipping

C. Procedure

☐ 1. Attach ground clamp to table or workpiece.

☐ 2. Select correct polarity for electrode.

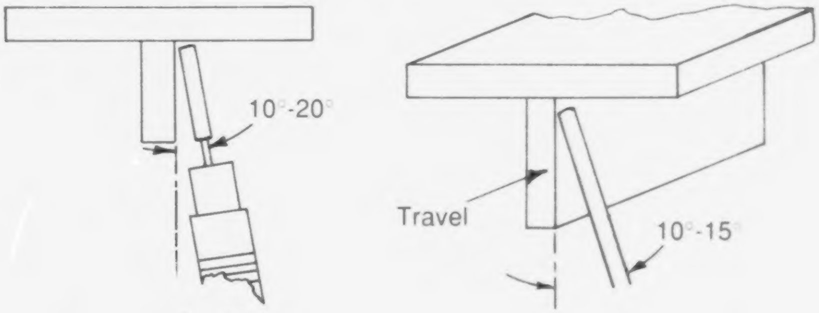
☐ 3. Turn on welding machine.

☐ 4. Adjust to correct amperage by running short beads on scrap material.

☐ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.

☐ 6. Place the joint so the weld will be in the correct position.

☐ 7. Place electrode in holder as indicated.



Front View

☐ 8. Start an arc and adjust electrode to correct arc length.

☐ 9. Adjust travel speed and electrode angle as required to make correct bead shape.

☐ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.

☐ 11. Secure the workpiece with pliers, and chip and brush the weld.

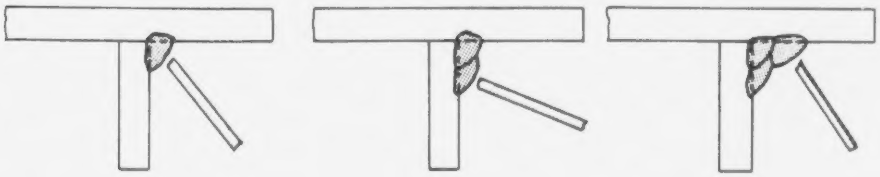
☐ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.

Job Sheet 21

☐ 13. Have your instructor check your work.

☐ 14. Weld other passes as required and be sure to clean and inspect each pass.

Top View



First Pass Rod Angle

Second Pass Rod Angle

Third Pass Rod Angle

☐ 15. Have your instructor check your work.

☐ 16. Repeat procedure for other side of joint, if required by your instructor.

☐ 17. Clean and inspect all passes.

☐ 18. Have your instructor check your work.

☐ 19. Turn off machine.

☐ 20. Check in tools and materials and clean area, or prepare for next job sheet, as directed by instructor.

Evaluator's comments: ______________________________

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Equipment, Applications, and Techniques
Unit 2

Job Sheet 22—Weld to Specifications a Fillet Weld Lap Joint in the Overhead Position with an E7018 Electrode

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

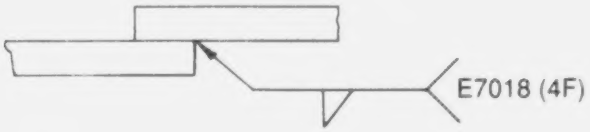
Evaluation criteria	**Rating**
Equipment setup and safety	______
First bead quality	______
Quality after break test	______
Quality of other beads	______

A. Tools and materials

SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Fitter's hammer
Bench vise
Mild steel plates as selected by instructor
Welding helmet and safety glasses

B. Specifications

1. Joint design and weld symbol:



2. Filler metal and number of beads: E7018, $\frac{1}{8}$" or $\frac{5}{32}$", single pass

3. Electrical characteristics: AC or DC+

4. Position: 4F

Job Sheet 22

5. Direction of welding: N/A

6. Cleaning: Chip and wire brush

7. Testing: Visual and break test

8. Technique: Drag

C. Procedure

☐ 1. Attach ground clamp to table or workpiece.

☐ 2. Select correct polarity for electrode.

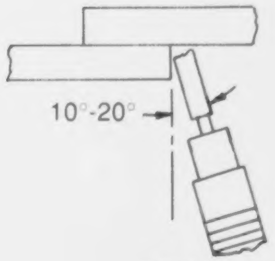
☐ 3. Turn on welding machine.

☐ 4. Adjust to correct amperage by running short beads on scrap material.

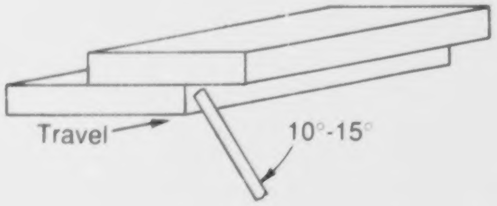
☐ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.

☐ 6. Place the joint so the weld will be in the correct position.

☐ 7. Place electrode in holder as indicated.



Front View



☐ 8. Start an arc and adjust electrode to correct arc length.

☐ 9. Adjust travel speed and electrode angle as required to make correct bead shape.

☐ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.

☐ 11. Secure the workpiece with pliers, and chip and brush the weld.

☐ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.

Job Sheet 22

☐ 13. Have your instructor check your work.

☐ 14. Break test the plates by placing one plate securely in a vise and hammering on the back side of the other plate.

☐ 15. Inspect bead to see if it breaks in the middle as it should and to make sure it has even penetration on both plates.

☐ 16. Tack weld plates back together, if required by instructor.

Note: The following three items are optional, depending on your instructor's directions.

☐ 17. Adjust machine, electrode angle, and travel speed as required and weld other side of joint.

☐ 18. Secure workpiece with pliers, and chip and brush.

☐ 19. Inspect and test weld.

☐ 20. Have your instructor check your work.

☐ 21. Turn off machine.

☐ 22. Check in tools and materials and clean area, or prepare for next job sheet, as directed by instructor.

Evaluator's comments: ______________________________

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Equipment, Applications, and Techniques
Unit 2

Job Sheet 23—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Overhead Position with an E7018 Electrode

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

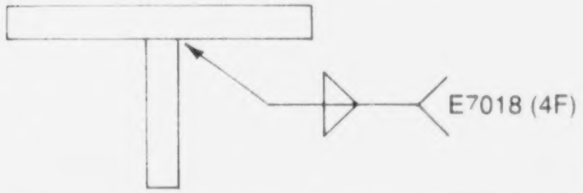
Evaluation criteria	**Rating**
Equipment setup and safety	______
First bead quality	______
Quality of other beads	______

A. Tools and materials

SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Mild steel plates as selected by instructor
Welding helmet and safety glasses

B. Specifications

1. Joint design and weld symbol:



2. Filler metal and number of beads: E7018, ⅛″ or 5⁄32″, three passes
3. Electrical characteristics: DC+ or AC
4. Position: 4F
5. Direction of welding: N/A

Job Sheet 23

6. Cleaning: Chip and wire brush
7. Testing: Visual
8. Technique: Drag

C. Procedure

☐ 1. Attach ground clamp to table or workpiece.

☐ 2. Select correct polarity for electrode.

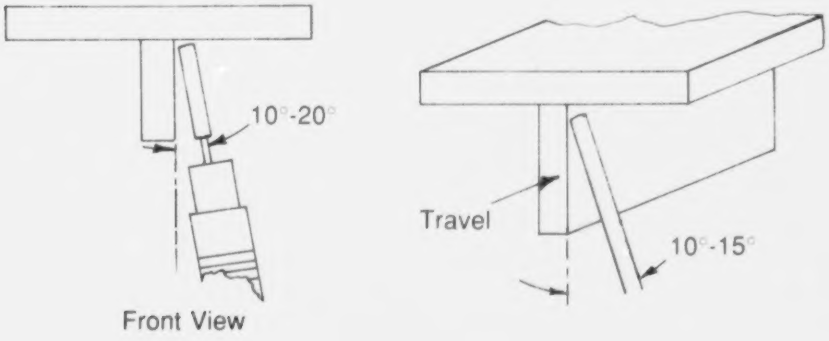
☐ 3. Turn on welding machine.

☐ 4. Adjust to correct amperage by running short beads on scrap material.

☐ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.

☐ 6. Place the joint so the weld will be in the correct position.

☐ 7. Place electrode in holder as indicated.



☐ 8. Start an arc and adjust electrode to correct arc length.

☐ 9. Adjust travel speed and electrode angle as required to make correct bead shape.

☐ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.

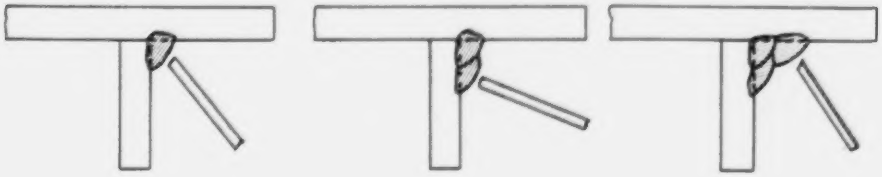
☐ 11. Secure the workpiece with pliers, and chip and brush the weld.

☐ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.

Job Sheet 23

☐ 13. Have your instructor check your work.

☐ 14. Weld other passes as required and be sure to clean and inspect each pass.



Top View

First Pass Rod Angle

Second Pass Rod Angle

Third Pass Rod Angle

☐ 15. Have your instructor check your work.

☐ 16. Repeat procedure for other side of joint, if required by your instructor.

☐ 17. Clean dn inspect all passes.

☐ 18. Have your instructor check your work.

☐ 19. Turn off machine.

☐ 20. Check in tools and materials and clean area, or prepare for next job sheet, as directed by instructor.

Evaluator's comments: ____

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Equipment, Applications, and Techniques
Unit 2

Job Sheet 24—Weld to Specifications a V-Groove Butt Joint in the Flat Position with an E6010 Electrode

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

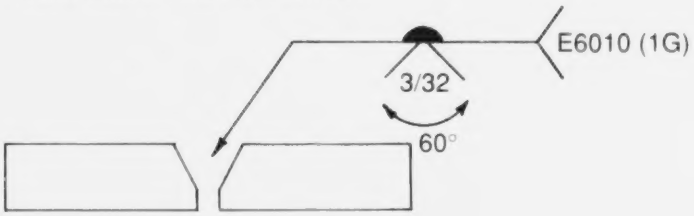
Evaluation criteria	**Rating**
Equipment setup and safety	____
Bevel layout and cutting	____
Bevel grinding and preparation	____
First bead quality	____
Weld quality after bend test	____

A. Tools and materials

SMAW machine with accessories
Personal safety clothing
Pliers
Chipping hammer and wire brush
Portable hand grinder
Oxyacetylene cutting unit
Soapstone
Straightedge
Cutting goggles
Sparklighter
File
Mild steel plate, 3/8"
Gap wire, 3/32"
Bevel square
Welding helmet and safety glasses

B. Specifications

1. Joint design and weld symbol:



2. Filler metal and number of beads: E6010, 1/8" or 5/32"

Job Sheet 24

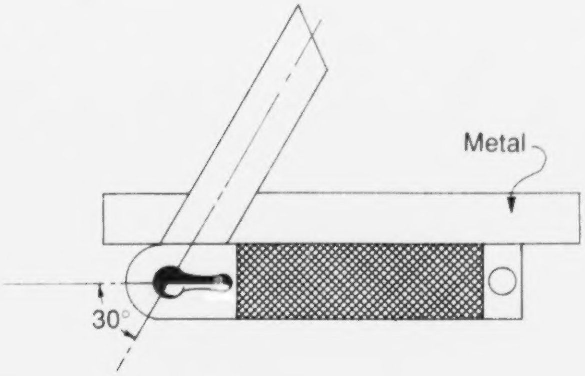
3. Electrical characteristics: DC+
4. Position: 1G
5. Direction of welding: N/A
6. Cleaning: Chip and wire brush
7. Testing: Visual and bend test
8. Technique: Whipping

C. Procedure

☐ 1. Check work area to make sure it is free of flammable materials and well ventilated, and note the location of the nearest fire extinguisher.

☐ 2. Place plates to be beveled on cutting table.

☐ 3. Measure with the bevel square and mark the long side of the plate for a 30° bevel.



☐ 4. Light and adjust torch.

☐ 5. Place torch at a right angle to the plate and tilt 30° off the line to make the bevel cut on both plates.

Note: Beveling may be accomplished with a track torch as directed by your instructor, and you may be directed to bevel several plates at this time in order to save time in future job sheets.

☐ 6. Turn off torch and secure system.

Job Sheet 24

☐ 7. Secure plates in a vise one at a time, grind mill scale and slag from all surface areas to be welded, and be very careful to retain the 30° bevel angle.

☐ 8. Grind $\frac{1}{16}$" to $\frac{1}{8}$" root face along the entire length of the thinnest part of the bevel on all plates.

☐ 9. Attach ground clamp to worktable or workpiece.

☐ 10. Select correct polarity for electrode.

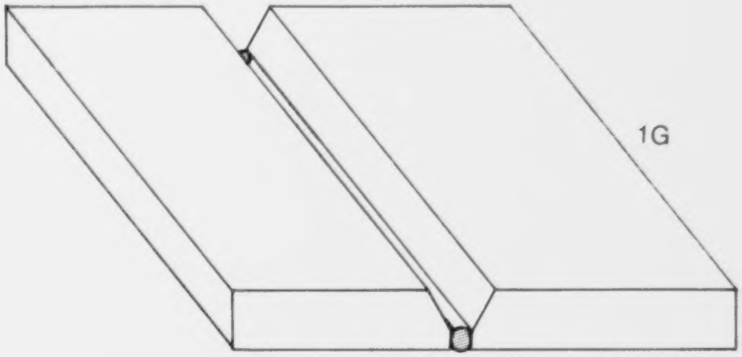
☐ 11. Turn on machine.

☐ 12. Put on safety gear and adjust to correct amperage by running a few test beads on scrap metal.

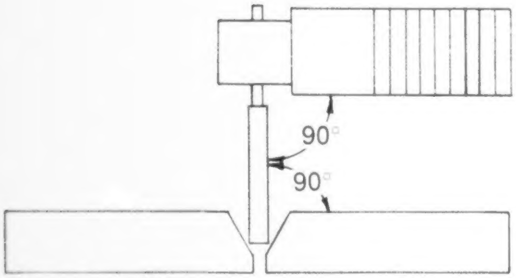
☐ 13. Align two plates face down on the work table, using a $\frac{3}{32}$" gap wire to properly align and space them.

☐ 14. Tack both ends of the joint and remove gap wire.

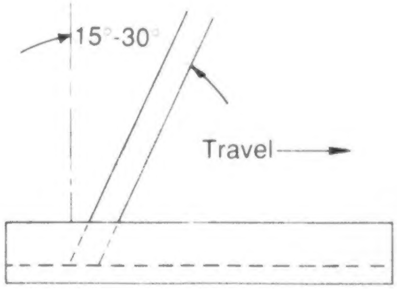
☐ 15. Position the plates so that the joint is in the position indicated in specifications.



☐ 16. Place electrode in holder and adjust to correct electrode angle over the joint.



Front View

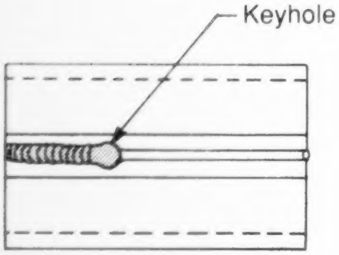


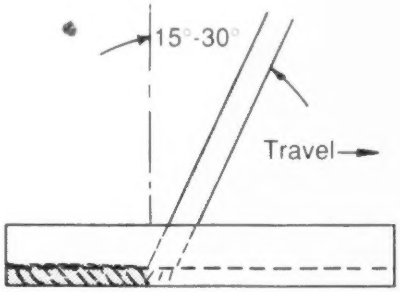
Side View

☐ 17. Start an arc and adjust electrode to correct arc length.

☐ 18. Make a puddle and immediately allow the keyhole to form.

Note: When the keyhole is properly formed, it allows the filler metal to completly penetrate the joint.





☐ 19. Whip the rod slightly forward to allow the keyhole to solidify, then whip the rod back to deposit more metal in the keyhole.

Note: Do not deposit filler metal outside the keyhole as you whip the rod away from the keyhole, and make sure your electrode is arcing in the bottom of the joint and not along the bevel.

Job Sheet 24

☐ 20. Make a tie-in at any point where the electrode is used up with the following procedure:

   a. Clean slag off the pass just completed with the chipping hammer and a wire brush.

   b. Grind the root pass with a portable grinder, and feather the end of the pass so that it becomes a little thinner near the keyhole pass.

☐ 21. Restart the arc deep in the groove at a point no more than ¼" from the keyhole, and hold a long arc to heat that portion of the pass.

☐ 22. Make another puddle and immediately continue with the keyhole and the slight whipping motion back and forth to keep it moving.

☐ 23. Repeat the procedure as required until the joint is completely welded.

☐ 24. Secure workpiece with pliers and clean and inspect root pass on both sides to make sure penetration is 100%.

☐ 25. Grind the entire length of the root pass.

☐ 26. Increase amperage on welding machine about 5 to 10 amps (if required).

☐ 27. Use a whipping technique to run a second pass over the entire length of the root pass, taking care not to blow a hole through the root pass.

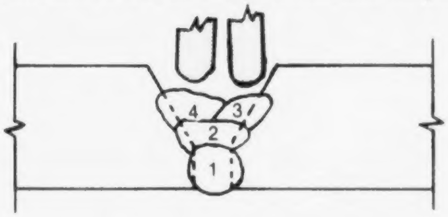
☐ 28. Secure workpiece with pliers and clean and inspect second pass to make sure it has good tie-in with the root pass.

☐ 29. Grind the entire length of the second pass, if required.

☐ 30. Adjust amperage to proper setting for electrode.

☐ 31. Use a whipping technique to lay stringer beads for remainder of fill-up and clean each stringer before starting next pass.

Note: Numbers in the illustration indicate sequence, not quantity.

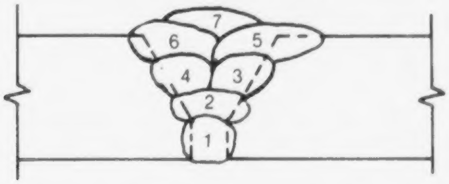


Job Sheet 24

☐ 32. Clean fill-up stringer beads thoroughly to prepare for a cap pass.

☐ 33. Use a whipping technique to lay stringer beads for the cap so that they pyramid from the toes to the face with the final cap stringer in approximately the center of the joint.

Note: The total height of the cap pass should not exceed ⅛″ and the sequence has to be followed carefully to accomplish this.



☐ 34. Clean and inspect cap pass.

☐ 35. Have your instructor check your work.

☐ 36. Turn off machine.

☐ 37. Bend test as directed in Job Sheet 25.

☐ 38. Check in tools and materials and clean area, or prepare for next job sheet, as directed by the instructor.

Evaluator's comments: ______________________________

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Equipment, Applications, and Techniques
Unit 2

Job Sheet 25—Bend Test a Welded V-Groove Joint

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Equipment setup and safety	______
Specimens cut perpendicular to weld	______
Specimens ground in same direction as weld	______
Proper face bend test on plunger	______
Proper root bend test on plunger	______
Proper inspection of face and root bends	______

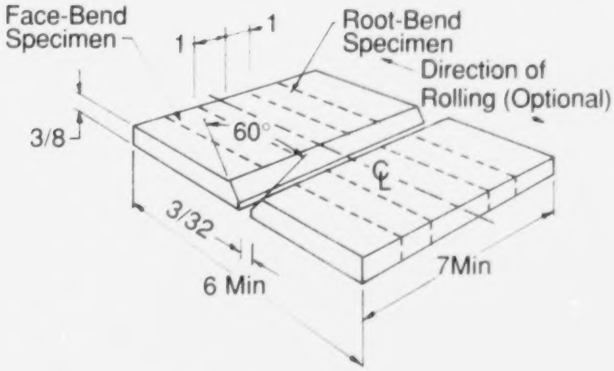
A. Tools and materials

- Bend test machine
- Groove-weld test plate
- Oxyacetylene cutting unit
- Portable hand grinder
- File and Pliers
- Personal safety clothing, and equipment
- Soapstone and Straightedge
- Cutting goggles and safety glasses
- Sparklighter

B. Procedure

☐ 1. Check work area to make sure it is free of flammable materials and well ventilated, and note the location of the nearest fire extinguisher.

☐ 2. Place test plate out on the worktable in front of you; use the straightedge and soapstone to mark off bend specimens for a face bend and a root bend; mark specimens F and R for identification.



Job Sheet 25

☐ 3. Set up oxyacetylene equipment, light and adjust cutting flame, and cut the specimens perpendicular to the weld as marked.

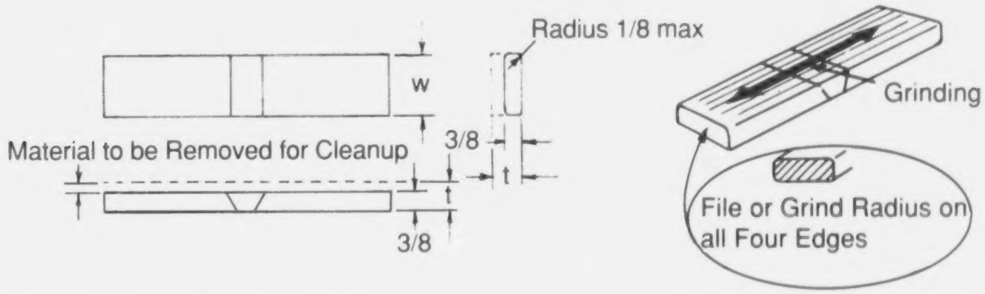
☐ 4. Turn off torch and shut down cutting unit.

☐ 5. Permit specimens to air cool, but do not quench them in water or they will be unsuitable for testing.

☐ 6. Take cooled specimens one at a time, secure in a vise, and use a portable grinder to grind to the following specifications:

a. A face bend specimen for a plunger-type tester should be a minimum of 6" long, and 1½" wide, and should be ground in the same direction as the weld with the face of the weld flush with the surface of the specimen.

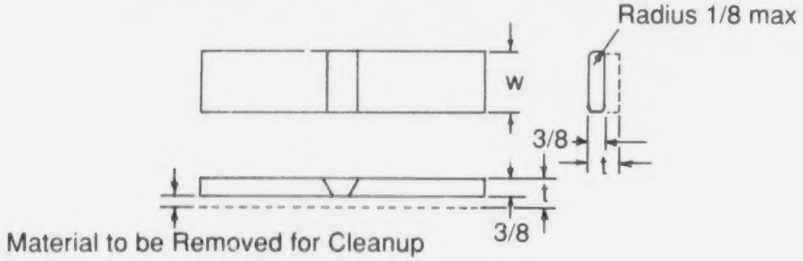
Note: A wrap-around tester will require a longer specimen.


Radius 1/8 max
w
Material to be Removed for Cleanup
3/8
t
t
3/8
Grinding
File or Grind Radius on all Four Edges

Courtesy Lincoln Electric Company

b. A root bend specimen for a plunger-type tester should be a minimum of 6" long, and 1½" wide, and should be ground in the same direction as the weld so that the root of the weld is flush with the surface of the specimen.

Note: A wrap-around tester will require a longer specimen.

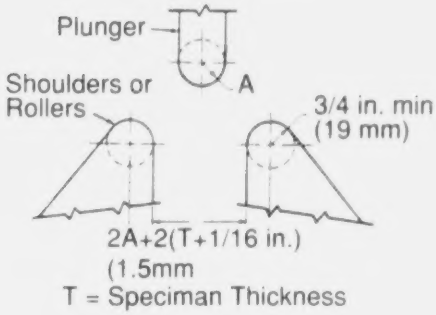

Radius 1/8 max
w
3/8
t
t
3/8
Material to be Removed for Cleanup

Courtesy Lincoln Electric Company

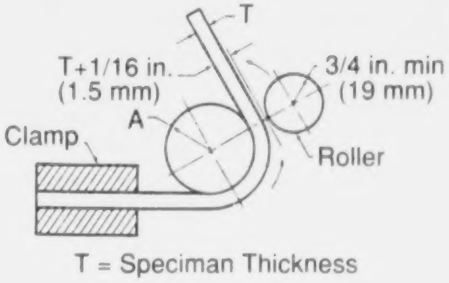
Job Sheet 25

☐ 7. Grind or file the corners of both specimens so that they have a ⅛" radius.

☐ 8. Take specimens to plunger-type tester and make bends according to the following procedure:


Plunger
A
Shoulders or Rollers
3/4 in. min (19 mm)
2A+2(T+1/16 in.) (1.5mm
T = Speciman Thickness

Guided Bend Test Jig


T
T+1/16 in. (1.5 mm)
A
3/4 in. min (19 mm)
Clamp
Roller
T = Speciman Thickness

Wrap-Around Bend Test Jig

Courtesy American Welding Society

a. Place the face bend specimen on the die member of the jig with the face of the weld pointing into the die so that the plunger is on the root side of the weld.

b. Actuate the plunger to force the specimen between the plunger and the die until it is formed into a U shape.

Caution: Always wear safety glasses when conducting bend tests.

c. Release pressure on plunger to release the specimen from the die.

☐ 9. Repeat the testing procedure for the root bend, but reverse the root and face of the weld as you place it on the die.

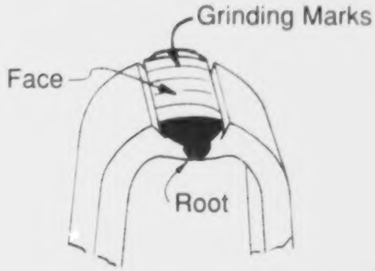
☐ 10. Inspect test specimens according to the following procedure:

a. Examine convex surface of both specimens for cracks or other open defects.

b. Check root bend to determine if weld has complete penetration through the joint.

Job Sheet 25

c. Check face bend to determine if there is complete fusion of the beveled edges with the weld.



☐ 11. Have your instructor check your bend test.

☐ 12. Check in tools and materials and clean area, or prepare for next job sheet, as directed by instructor.

Evaluator's comments: ____________________

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Equipment, Applications, and Techniques
Unit 2

Job Sheet 26—Weld to Specifications a V-Groove Butt Joint in the Horizontal Position with an E6010 Electrode

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

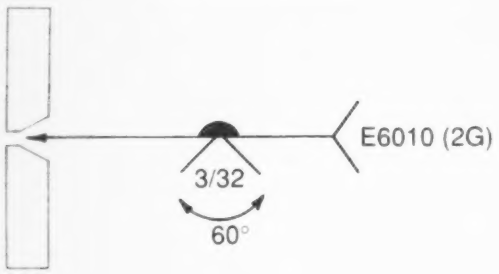
Evaluation criteria	**Rating**
Equipment setup and safety	______
Measuring and cutting joint	______
Root face preparation	______
Use of gap wire and tack welds	______
Root pass quality	______
Cleaning and inspection of passes	______
Total weld quality	______

A. Tools and materials

- SMAW machine with accessories
- Bend test machine
- Personal safety clothing, equipment, and glasses
- Pliers
- Chipping hammer and wire brush
- Portable hand grinder
- Oxyacetylene cutting unit
- Soapstone
- Straightedge
- Cutting goggles
- Sparklighter
- File
- Mild steel plate, as selected by instructor
- Gap wire, 3/32"
- Bevel square
- Welding helmet

B. Specifications

1. Joint design and weld symbol:



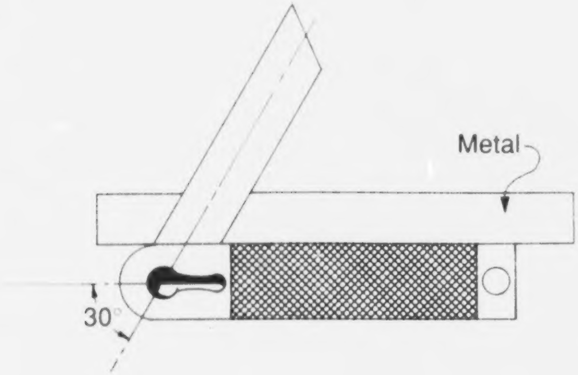
2. Filler metal and number of beads: E6010, 3/32″ or 1/8″
3. Electrical characteristics: DC+
4. Position: 2G
5. Direction of welding: N/A
6. Cleaning: Chip, wire brush, and grind
7. Testing: Visual and bend test
8. Technique: Whipping

C. Procedure

☐ 1. Check work area to make sure it is free of flammable materials and well ventilated, and note the location of the nearest fire extinguisher.

☐ 2. Place plates to be beveled on cutting table.

☐ 3. Measure with the bevel square and mark the long side of the plate for a 30° bevel.



☐ 4. Light and adjust torch.

☐ 5. Place torch at a right angle to the plate and tilt 30° off the line to make the bevel cut on both plates.

Note: Beveling may be accomplished with a track torch as directed by your instructor, and you may be directed to bevel several plates at this time in order to save time in future job sheets.

☐ 6. Turn off torch and secure system.

Job Sheet 26

☐ 7. Secure plates in a vise one at a time, grind mill scale and slag from all surface areas to be welded, and be very careful to retain the 30° bevel angle.

☐ 8. Grind $\frac{1}{16}$" to $\frac{1}{8}$" root face along the entire length of the thinnest part of the bevel on all plates.

☐ 9. Attach ground clamp to worktable or workpiece.

☐ 10. Select correct polarity for electrode.

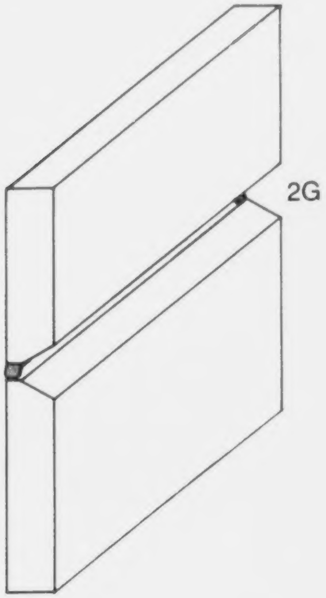
☐ 11. Turn on machine.

☐ 12. Put on safety gear and adjust to correct amperage by running a few test beads on scrap metal.

☐ 13. Align two plates face down on the work table, using a $\frac{3}{32}$" gap wire to properly align and space them.

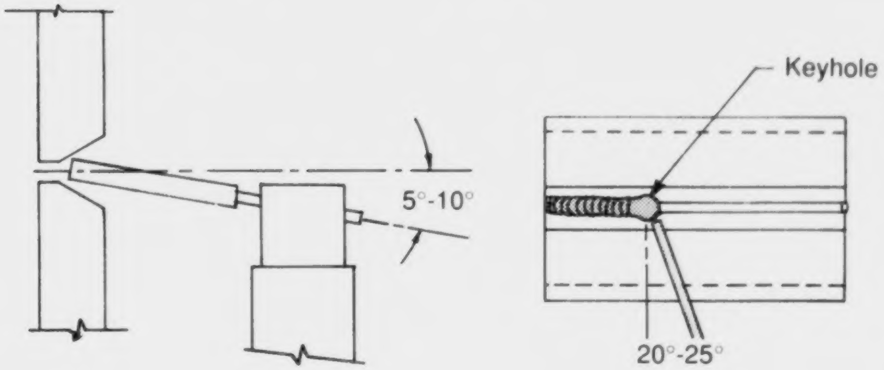
☐ 14. Tack both ends of the joint and remove gap wire.

☐ 15. Position the plates so that the joint is in the position indicated in specifications.



Job Sheet 26

☐ 16. Place electrode in holder and adjust to correct electrode angle over the joint.



Front View Side View

☐ 17. Start an arc and adjust electrode to correct arc length.

☐ 18. Make a puddle and immediately allow the keyhole to form by pushing the electrode through the joint and keeping it flush with the backside of the joint.

Note: When the keyhole is properly formed, it allows the filler metal to completly penetrate the joint.

☐ 19. Whip the rod slightly forward to allow the keyhole to solidify, then whip the rod back to deposit more metal in the keyhole.

Note: Do not deposit filler metal outside the keyhole as you whip the rod away from the keyhole, and make sure your electrode is arcing in the bottom of the joint and not along the bevel.

☐ 20. Make a tie-in at any point where the electrode is used up with the following procedure:

a. Clean slag off the pass just completed with the chipping hammer and a wire brush.

b. Grind the root pass with a portable grinder, and feather the end of the pass so that it becomes a little thinner near the keyhole pass.

Note: Make other tie-ins with this same procedure.

Job Sheet 26

☐ 21. Restart the arc deep in the groove at a point no more than ¼" from the keyhole, and hold a long arc to heat that portion of the pass.

☐ 22. Make another puddle and immediately continue with the keyhole and the slight whipping motion back and forth to keep it moving.

☐ 23. Repeat the procedure as required until the joint is completely welded.

☐ 24. Secure workpiece with pliers and clean and inspect root pass on both sides to make sure penetration is 100%.

☐ 25. Grind the entire length of the root pass.

☐ 26. Increase amperage on welding machine about 5 to 10 amps (if required).

☐ 27. Use a whipping technique to run a second pass over the entire length of the root pass, taking care not to blow a hole through the root pass.

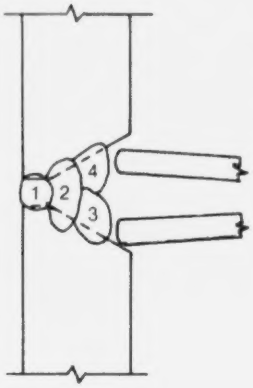
☐ 28. Secure workpiece with pliers and clean and inspect second pass to make sure it has good tie-in with the root pass.

☐ 29. Grind the entire length of the hot pass, if required.

☐ 30. Adjust amperage to proper setting for electrode.

☐ 31. Use a whipping technique to lay stringer beads for remainder of fill-up and clean each stringer before starting next pass.

Note: Numbers in the illustration indicate sequence, not quantity.

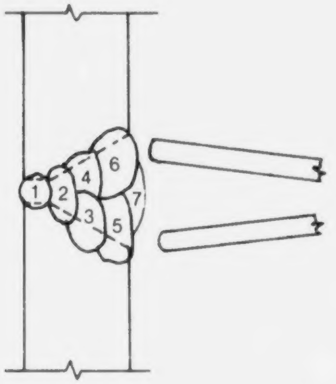


Job Sheet 26

☐ 32. Clean fill-up stringer beads thoroughly to prepare for a cap pass.

☐ 33. Use a whipping technique to lay stringer beads for the cap so that they have a convex shape from the toes to the face of the cap.

Note: The total height of the cap pass should not exceed ⅛" and the sequence has to be followed carefully so that the last bead is in the center to control cooling.



☐ 34. Clean and inspect cap pass.

☐ 35. Have your instructor check your work.

☐ 36. Turn off machine.

☐ 37. Bend test as directed in Job Sheet 25.

☐ 38. Check in tools and materials and clean area, or prepare for next job sheet, as directed by the instructor.

Evaluator's comments: ____________________

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Equipment, Applications, and Techniques
Unit 2

Job Sheet 27—Weld to Specifications a V-Groove Butt Joint in the Vertical Position with an E6010 Electrode

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

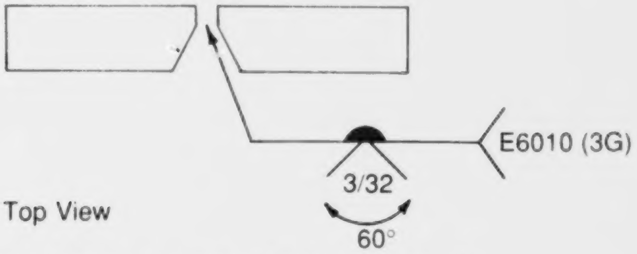
Evaluation criteria	**Rating**
Equipment setup and safety	______
Measuring and cutting joint	______
Root face preparation	______
Use of gap wire and tack welds	______
Root pass quality	______
Cleaning and inspection of passes	______
Total weld quality	______

A. Tools and materials

SMAW machine with accessories
Personal safety clothing
Pliers
Chipping hammer and wire brush
Portable hand grinder
Oxyacetylene cutting unit
Soapstone
Straightedge
Cutting goggles
Sparklighter
File
Mild steel plate as selected by instructor
Gap wire, 3/32″
Bevel square
Bend test machine
Welding helmet and safety glasses

B. Specifications

1. Joint design and weld symbol:



2. Filler metal and number of beads: E6010, 3/32″ or 1/8″

Job Sheet 27

3. Electrical characteristics: DC+

4. Position: 3G

5. Direction of welding: Vertical up

6. Cleaning: Chip, wire brush, and grind

7. Testing: Visual and bend test

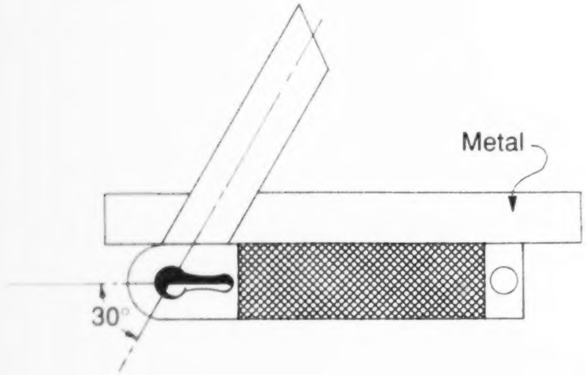
8. Technique: Whipping or weave bead

C. Procedure

☐ 1. Check work area to make sure it is free of flammable materials and well ventilated, and note the location of the nearest fire extinguisher.

☐ 2. Place plates to be beveled on cutting table.

☐ 3. Measure with the bevel square and mark the long side of the plate for a 30° bevel.



☐ 4. Light and adjust torch.

☐ 5. Place torch at a right angle to the plate and tilt 30° off the line to make the bevel cut on both plates.

Note: Beveling may be accomplished with a track torch as directed by your instructor, and you may be directed to bevel several plates at this time in order to save time in future job sheets.

☐ 6. Turn off torch and secure system.

Job Sheet 27

☐ 7. Secure plates in a vise one at a time, grind mill scale and slag from all surface areas to be welded, and be very careful to retain the 30° bevel angle.

☐ 8. Grind $\frac{1}{16}$″ to $\frac{1}{8}$″ root face along the entire length of the thinnest part of the bevel on all plates.

☐ 9. Attach ground clamp to worktable or workpiece.

☐ 10. Select correct polarity for electrode.

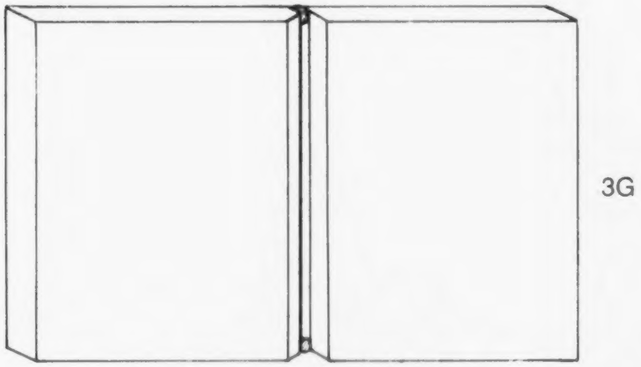
☐ 11. Turn on machine.

☐ 12. Put on safety gear and adjust to correct amperage by running a few test beads on scrap metal.

☐ 13. Align two plates face down on the work table, using a $\frac{3}{32}$″ gap wire to properly align and space them.

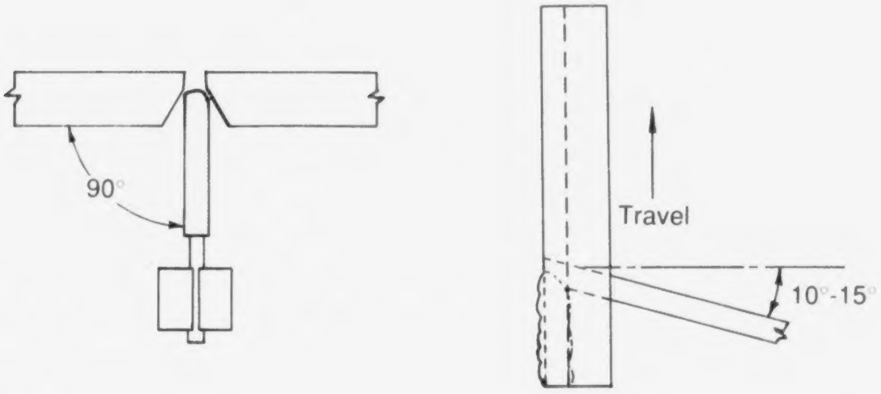
☐ 14. Tack both ends of the joint and remove gap wire.

☐ 15. Position the plates so that the joint is in the position indicated in specifications.



Job Sheet 27

☐ 16. Place electrode in holder and adjust to correct electrode angle over the joint.

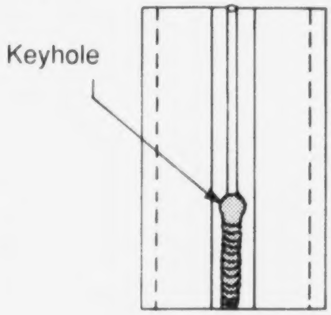


Top View Side View

☐ 17. Start an arc and adjust electrode to correct arc length.

☐ 18. Make a puddle and immediately allow the keyhole to form.

Note: When the keyhole is properly formed, it allows the filler metal to complely penetrate the joint.



Front View

☐ 19. Whip the rod slightly forward to allow the keyhole to solidify, then whip the rod back to deposit more metal in the keyhole.

Note: Do not deposit filler metal outside the keyhole as you whip the rod away from the keyhole, and make sure your electrode is arcing in the bottom of the joint and not along the bevel.

Job Sheet 27

☐ 20. Make a tie-in at any point where the electrode is used up with the following procedure:

- a. Clean slag off the pass just completed with the chipping hammer and a wire brush.
- b. Grind the root pass with a portable grinder, and feather the end of the pass so that it becomes a little thinner near the keyhole pass.

  Note: Make other tie-ins with this same procedure.

☐ 21. Restart the arc deep in the groove at a point no more than ¼" from the keyhole, and hold a long arc to heat that portion of the pass.

☐ 22. Make another puddle and immediately continue with the keyhole and the slight whipping motion back and forth to keep it moving.

☐ 23. Repeat the procedure as required until the joint is completely welded.

☐ 24. Secure workpiece with pliers and clean and inspect root pass on both sides to make sure penetration is 100%.

☐ 25. Grind the entire length of the root pass.

☐ 26. Increase amperage on welding machine about 5 to 10 amps (if required).

☐ 27. Use a whipping technique to run a second pass over the entire length of the root pass, taking care not to blow a hole through the root pass.

☐ 28. Secure workpiece with pliers and clean and inspect second pass to make sure it has good tie-in with the root pass.

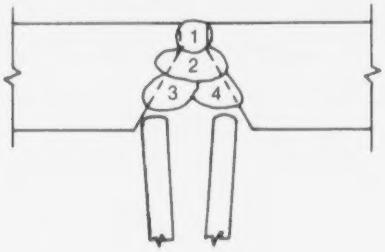
☐ 29. Grind the entire length of the hot pass, if required.

☐ 30. Adjust amperage to proper setting for electrode.

Job Sheet 27

☐ 31. Use a whipping or weave technique to lay beads for remainder of fill-up, and clean each stringer before starting next pass.

Note: Numbers in the illustration indicate sequence, not quantity.

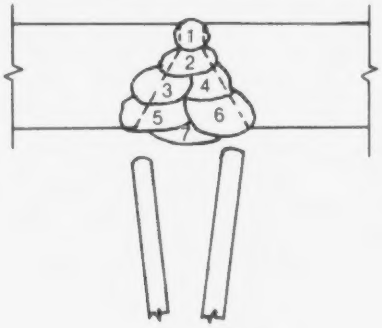


Top View

☐ 32. Clean fill-up stringer beads thoroughly to prepare for a cap pass.

☐ 33. Use a whipping or weave technique to lay beads for the cap.

Note: The total height of the cap pass should not exceed ⅛″ and the sequence has to be followed carefully to accomplish this.



Top View

☐ 34. Clean and inspect cap pass.

☐ 35. Have your instructor check your work.

☐ 36. Turn off machine.

☐ 37. Bend test as specified.

Job Sheet 27

☐ 38. Check in tools and materials and clean area, or prepare for next job sheet, as directed by the instructor.

Evaluator's comments: ______________________________

Equipment, Applications, and Techniques
Unit 2

Job Sheet 28—Weld to Specifications a V-Groove Butt Joint in the Overhead Position with an E6010 Electrode

Name ____________________ ____________________ Attempt Number ________

Date ____ Overall Rating ________

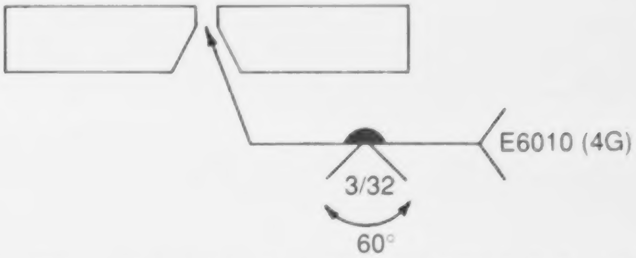
Evaluation criteria	Rating
Equipment setup and safety	______
Measuring and cutting joint	______
Root face preparation	______
Use of gap wire and tack welds	______
Root pass quality	______
Cleaning and inspection of passes	______
Total weld quality	______

A. Tools and materials

- SMAW machine with accessories
- Bend test machine
- Personal safety clothing
- Pliers
- Chipping hammer and wire brush
- Portable hand grinder
- Oxyacetylene cutting unit
- Soapstone
- Straightedge
- Cutting goggles
- Sparklighter
- File
- Mild steel plate as selected by instructor
- Gap wire, 3/32″
- Bevel square
- Welding helmet and safety glasses

B. Specifications

1. Joint design and weld symbol:



2. Filler metal and number of beads: E6010, 3/32″ or 1/8″

Job Sheet 28

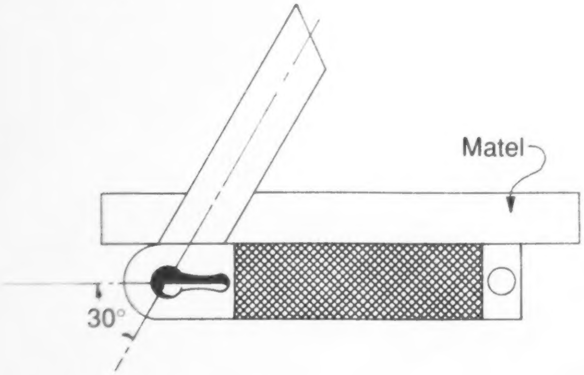
3. Electrical characteristics: DC+
4. Position: 4G
5. Direction of welding: N/A
6. Cleaning: Chip, wire brush, and grind
7. Testing: Visual and bend test
8. Technique: Whipping

C. Procedure

☐ 1. Check work area to make sure it is free of flammable materials and well ventilated, and note the location of the nearest fire extinguisher.

☐ 2. Place plates to be beveled on cutting table.

☐ 3. Measure with the bevel square and mark the long side of the plate for a 30° bevel.



☐ 4. Light and adjust torch.

☐ 5. Place torch at a right angle to the plate and tilt 30° off the line to make the bevel cut on both plates.

Note: Beveling may be accomplished with a track torch as directed by your instructor, and you may be directed to bevel several plates at this time in order to save time in future job sheets.

☐ 6. Turn off torch and secure system.

Job Sheet 28

☐ 7. Secure plates in a vise one at a time, grind mill scale and slag from all surface areas to be welded, and be very careful to retain the 30° bevel angle.

☐ 8. Grind $\frac{1}{16}$" to $\frac{1}{8}$" root face along the entire length of the thinnest part of the bevel on all plates.

☐ 9. Attach ground clamp to worktable or workpiece.

☐ 10. Select correct polarity for electrode.

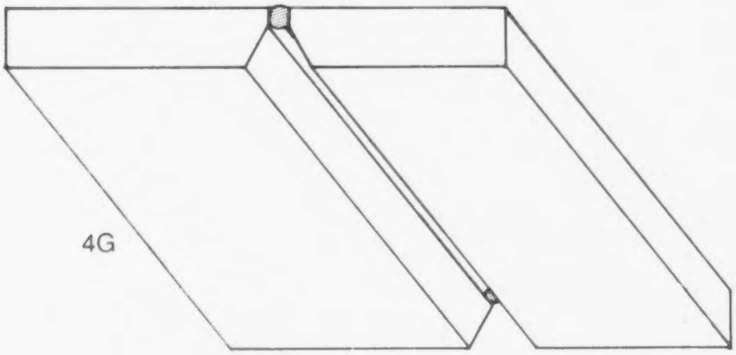
☐ 11. Turn on machine.

☐ 12. Put on safety gear and adjust to correct amperage by running a few test beads on scrap metal.

☐ 13. Align two plates face down on the worktable, using a $\frac{3}{32}$" gap wire to properly align and space them.

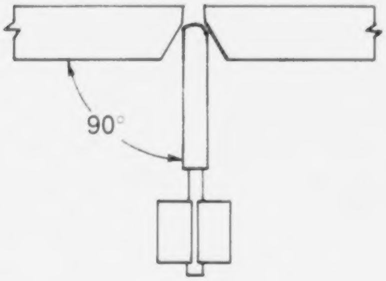
☐ 14. Tack both ends of the joint and remove gap wire.

☐ 15. Position the plates so that the joint is in the position indicated in specifications.

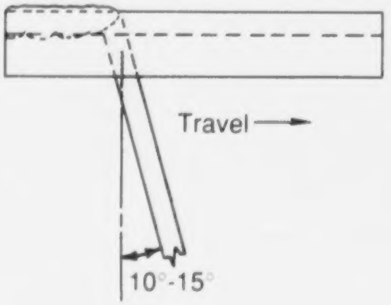


Job Sheet 28

☐ 16. Place electrode in holder and adjust to correct electrode angle over the joint.



Front View

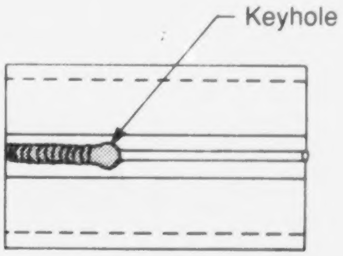


Side View

☐ 17. Start an arc and adjust electrode to correct arc length.

☐ 18. Make a puddle and immediately allow the keyhole to form.

Note: When the keyhole is properly formed, it allows the filler metal to completly penetrate the joint.



Bottom View

☐ 19. Whip the rod slightly forward to allow the keyhole to solidify, then whip the rod back to deposit more metal in the keyhole.

Note: Do not deposit filler metal outside the keyhole as you whip the rod away from the keyhole, and make sure your electrode is arcing in the bottom of the joint and not along the bevel.

Job Sheet 28

☐ 20. Make a tie-in at any point where the electrode is used up with the following procedure:

  a. Clean slag off the pass just completed with the chipping hammer and a wire brush.

  b. Grind the root pass with a portable grinder, and feather the end of the pass so that it becomes a little thinner near the keyhole pass.

☐ 21. Restart the arc deep in the groove at a point no more than ¼" from the keyhole, and hold a long arc to heat that portion of the pass.

☐ 22. Make another puddle and immediately continue with the keyhole and the slight whipping motion back and forth to keep it moving.

☐ 23. Repeat the procedure as required until the joint is completely welded.

☐ 24. Secure workpiece with pliers and clean and inspect root pass on both sides to make sure penetration is 100%.

☐ 25. Grind the entire length of the root pass.

☐ 26. Increase amperage on welding machine about 5 to 10 amps (if required).

☐ 27. Use a whipping technique to run a second pass over the entire length of the root pass, taking care not to blow a hole through the root pass.

☐ 28. Secure workpiece with pliers and clean and inspect second pass to make sure it has good tie-in with the root pass.

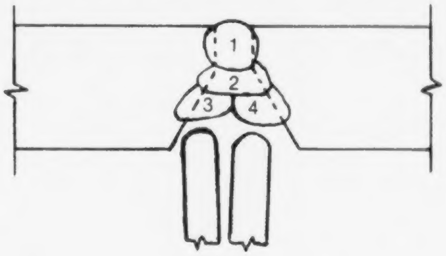
☐ 29. Grind the entire length of the hot pass, if required.

☐ 30. Adjust amperage to proper setting for electrode.

Job Sheet 28

☐ 31. Use a whipping technique to lay stringer beads for remainder of fill-up and clean each stringer before starting next pass.

Note: Numbers in the illustration indicate sequence, not quantity.

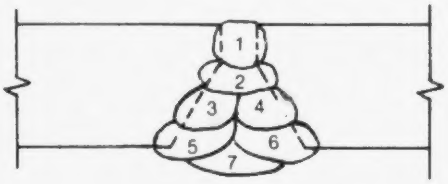


Front View

☐ 32. Clean fill-up stringer beads thoroughly to prepare for a cap pass.

☐ 33. Use a whipping technique to lay stringer beads for the cap so that they pyramid from the toes to the face with the final cap stringer in approximately the center of the joint.

Note: The total height of the cap pass should not exceed ⅛" and the sequence has to be followed carefully to accomplish this.



Front View

☐ 34. Clean and inspect cap pass.

☐ 35. Have your instructor check your work.

☐ 36. Turn off machine.

☐ 37. Bend test as specified.

Job Sheet 28

☐ 38. Check in tools and materials and clean area, or prepare for next job sheet, as directed by the instructor.

Evaluator's comments: ______________________________

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Equipment, Applications, and Techniques
Unit 2

Job Sheet 29—Weld to Specifications a V-Groove Butt Joint in the Flat Position with an E6010 Electrode Root and an E7018 Electrode Fill and Cap

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

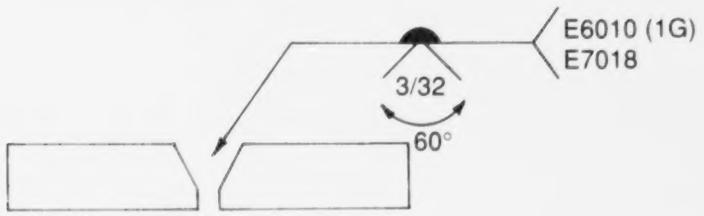
Evaluation criteria	**Rating**
Equipment setup and safety	______
Joint and root face preparation	______
Use of gap wire and tack welds	______
Root pass quality	______
Second and other pass quality with E7108	______
Final weld quality	______

A. Tools and materials

- SMAW machine with accessories
- Bend test machine
- Personal safety clothing
- Pliers
- Chipping hammer and wire brush
- Portable hand grinder
- Oxyacetylene cutting unit
- Soapstone
- Straightedge
- Cutting goggles
- Sparklighter
- File
- Mild steel plate as selected by instructor
- Gap wire, $\frac{3}{32}$"
- Bevel square
- Welding helmet and safety glasses

B. Specifications

1. Joint design and weld symbol:



2. Filler metal and number of beads: E6010, E7018, $\frac{3}{32}$" or $\frac{1}{8}$"

Job Sheet 29

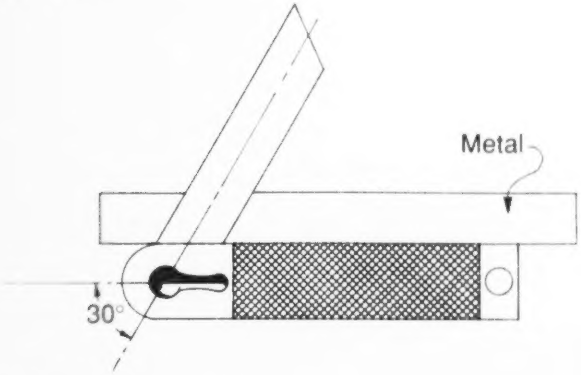
3. Electrical characteristics: DC+
4. Position: 1G
5. Direction of welding: N/A
6. Cleaning: Chip, wire brush, and grind
7. Testing: Visual and bend test
8. Technique: Drag

C. Procedure

☐ 1. Check work area to make sure it is free of flammable materials and well ventilated, and note the location of the nearest fire extinguisher.

☐ 2. Place plates to be beveled on cutting table.

☐ 3. Measure with the bevel square and mark the long side of the plate for a 30° bevel.



☐ 4. Light and adjust torch.

☐ 5. Place torch at a right angle to the plate and tilt 30° off the line to make the bevel cut on both plates.

Note: Beveling may be accomplished with a track torch as directed by your instructor, and you may be directed to bevel several plates at this time in order to save time in future job sheets.

☐ 6. Turn off torch and secure system.

Job Sheet 29

☐ 7. Secure plates in a vise one at a time, grind mill scale and slag from all surface areas to be welded, and be very careful to retain the 30° bevel angle.

☐ 8. Grind 1/16" to 1/8" root face along the entire length of the thinnest part of the bevel on all plates.

☐ 9. Attach ground clamp to worktable or workpiece.

☐ 10. Select correct polarity for electrode.

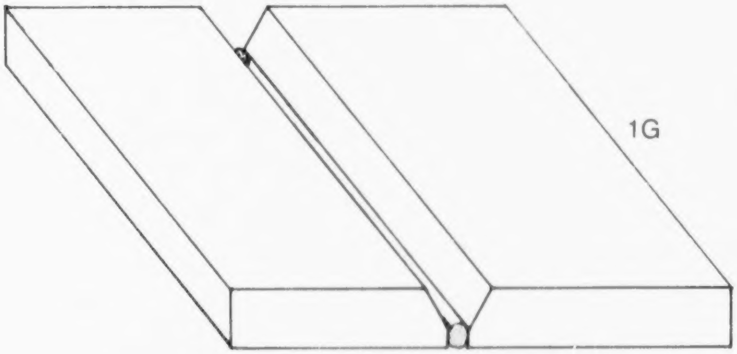
☐ 11. Turn on machine.

☐ 12. Put on safety gear and adjust to correct amperage by running a few test beads on scrap metal.

☐ 13. Align two plates face down on the worktable, using a 3/32" gap wire to properly align and space them.

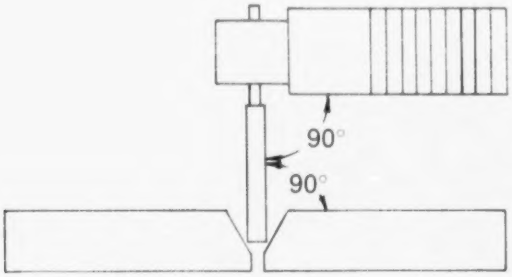
☐ 14. Tack both ends of the joint and remove gap wire.

☐ 15. Position the plates so that the joint is in the position indicated in specifications.

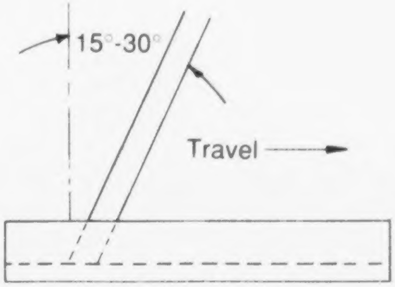


Job Sheet 29

☐ 16. Place electrode in holder and adjust to correct electrode angle over the joint.



Front View

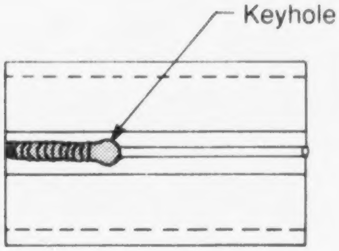


Side View

☐ 17. Start an arc and adjust electrode to correct arc length.

☐ 18. Make a puddle and immediately allow the keyhole to form.

Note: When the keyhole is properly formed, it allows the filler metal to completly penetrate the joint.



Top View

☐ 19. Whip the rod slightly forward to allow the keyhole to solidify, then whip the rod back to deposit more metal in the keyhole.

Note: Do not deposit filler metal outside the keyhole as you whip the rod away from the keyhole, and make sure your electrode is arcing in the bottom of the joint and not along the bevel.

Job Sheet 29

☐ 20. Make a tie-in at any point where the electrode is used up with the following procedure:

  a. Clean slag off the pass just completed with the chipping hammer and a wire brush.

  b. Grind the root pass with a portable grinder, and feather the end of the pass so that it becomes a little thinner near the keyhole pass.

☐ 21. Restart the arc deep in the groove at a point no more than ¼" from the keyhole, and hold a long arc to heat that portion of the pass.

☐ 22. Make another puddle and immediately continue with the keyhole and the slight whipping motion back and forth to keep it moving.

☐ 23. Repeat the procedure as required until the joint is completely welded.

☐ 24. Secure workpiece with pliers and clean and inspect root pass on both sides to make sure penetration is 100%.

☐ 25. Grind the entire length of the root pass.

☐ 26. Adjust amperage to proper setting for an E7018 electrode.

☐ 27. Use a drag technique to run a second pass over the entire length of the root pass, taking care not to blow a hole through the root pass.

☐ 28. Secure workpiece with pliers and clean and inspect second pass to make sure it has good tie-in with the root pass.

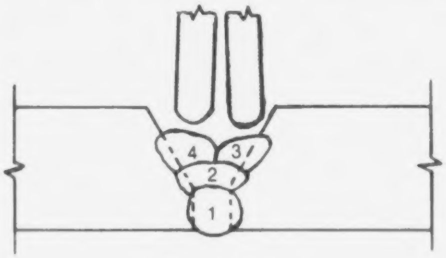
☐ 29. Grind the entire length of the second pass.

☐ 30. Adjust amperage to proper setting for an E7018 electrode.

Job Sheet 29

☐ 31. Use a drag technique to lay stringer beads for remainder of fill-up and clean each stringer before starting next pass.

Note: Numbers in the illustration indicate sequence, not quantity.

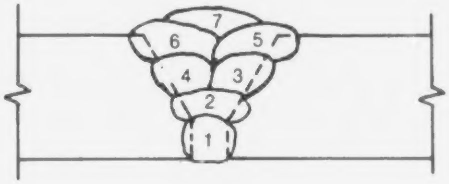


Front View

☐ 32. Clean fill-up stringer beads thoroughly to prepare for a cap pass.

☐ 33. Use a drag technique to lay stringer beads for the cap so that they pyramid from the toes to the face with the final cap stringer in approximately the center of the joint.

Note: The total height of the cap pass should not exceed ⅛″ and the sequence has to be followed carefully to accomplish this.



Front View

☐ 34. Clean and inspect cap pass.

☐ 35. Have your instructor check your work.

☐ 36. Turn off machine.

☐ 37. Bend test as specified.

Job Sheet 29

☐ 38. Check in tools and materials and clean area, or prepare for next job sheet, as directed by the instructor.

Evaluator's comments: ____

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Equipment, Applications, and Techniques
Unit 2

Job Sheet 30—Weld to Specifications a V-Groove Butt Joint in the Horizontal Position with an E6010 Electrode Root and an E7018 Electrode Fill and Cap

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

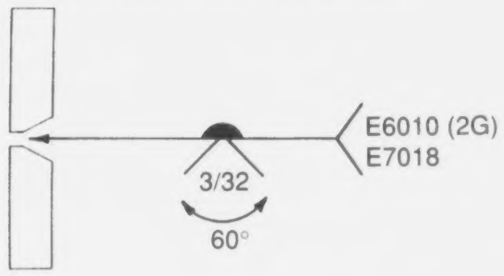
Evaluation criteria	**Rating**
Equipment setup and safety	______
Joint and root face preparation	______
Use of gap wire and tack welds	______
Root pass quality with E6010	______
Second and other pass quality with E7108	______
Final weld quality	______

A. Tools and materials

SMAW machine with accessories
Personal safety clothing
Pliers
Chipping hammer and wire brush
Portable hand grinder
Oxyacetylene cutting unit
Soapstone
Straightedge
Cutting goggles
Sparklighter
File
Mild steel plate as selected by instructor
Gap wire, 3/32"
Bevel square
Welding helmet and safety glasses

B. Specifications

1. Joint design and weld symbol:



Job Sheet 30

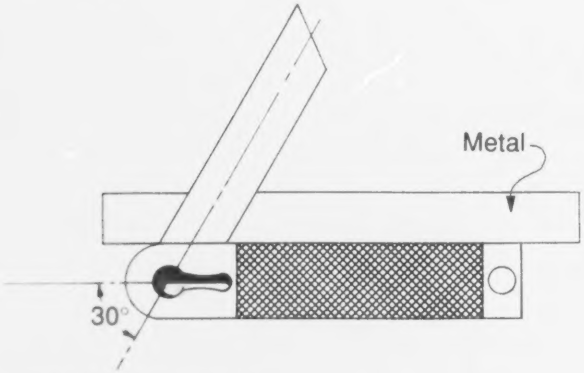
2. Filler metal and number of beads: E6010, E7018, 3/32" or 1/8"
3. Electrical characteristics: DC+
4. Position: 2G
5. Direction of welding: N/A
6. Cleaning: Chip, wire brush, and grind
7. Testing: Visual and bend test
8. Technique: Whip and drag

C. Procedure

☐ 1. Check work area to make sure it is free of flammable materials and well ventilated, and note the location of the nearest fire extinguisher.

☐ 2. Place plates to be beveled on cutting table.

☐ 3. Measure with the bevel square and mark the long side of the plate for a 30° bevel.



☐ 4. Light and adjust torch.

☐ 5. Place torch at a right angle to the plate and tilt 30° off the line to make the bevel cut on both plates.

Note: Beveling may be accomplished with a track torch as directed by your instructor, and you may be directed to bevel several plates at this time in order to save time in future job sheets.

☐ 6. Turn off torch and secure system.

Job Sheet 30

☐ 7. Secure plates in a vise one at a time, grind mill scale and slag from all surface areas to be welded, and be very careful to retain the 30° bevel angle.

☐ 8. Grind $\frac{1}{16}$" to $\frac{1}{8}$" root face along the entire length of the thinnest part of the bevel on all plates.

☐ 9. Attach ground clamp to worktable or workpiece.

☐ 10. Select correct polarity for electrode.

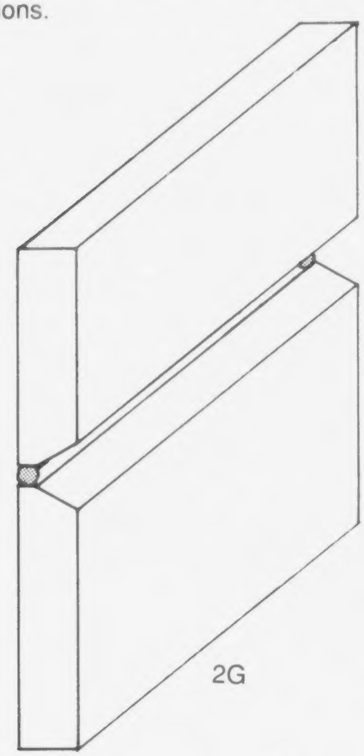
☐ 11. Turn on machine.

☐ 12. Put on safety gear and adjust to correct amperage by running a few test beads on scrap metal.

☐ 13. Align two plates face down on the worktable, using a $\frac{3}{32}$" gap wire to properly align and space them.

☐ 14. Tack weld both ends of the joint and remove gap wire.

☐ 15. Position the plates so that the joint is in the position indicated in specifications.



Job Sheet 30

☐ 16. Make a tie-in at any point where the electrode is used up with the following procedure:

  a. Clean slag off the pass just completed with the chipping hammer and a wire brush.

  b. Grind the root pass with a portable grinder, and feather the end of the pass so that it becomes a little thinner near the keyhole pass.

  Note: Make other tie-ins with this same procedure.

☐ 17. Restart the arc deep in the groove at a point no more than ¼″ from the keyhole, and hold a long arc to heat that portion of the pass.

☐ 18. Make another puddle and immediately continue with the keyhole and the slight whipping motion back and forth to keep it moving.

☐ 19. Repeat the procedure as required until the joint is completely welded.

☐ 20. Secure workpiece with pliers and clean and inspect root pass on both sides to make sure penetration is 100%.

☐ 21. Grind the entire length of the root pass.

☐ 22. Adjust amperage to proper setting for an E7018 electrode.

☐ 23. Use a drag technique to run a second pass over the entire length of the root pass, taking care not to blow a hole through the root pass.

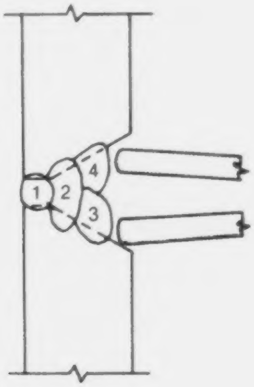
☐ 24. Secure workpiece with pliers and clean and inspect second pass to make sure it has good tie-in with the root pass.

☐ 25. Grind the entire length of the second pass.

Job Sheet 30

☐ 26. Use a drag technique to lay stringer beads for remainder of fill-up and clean each stringer before starting next pass.

Note: Numbers in the illustration indicate sequence, not quantity.

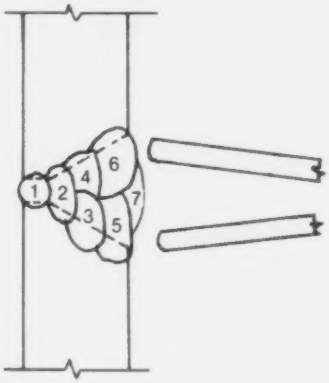


Front View

☐ 27. Clean fill-up stringer beads thoroughly to prepare for a cap pass.

☐ 28. Use a drag technique to lay stringer beads for the cap so that they pyramid from the toes to the face with the final cap stringer in approximately the center of the joint.

Note: The total height of the cap pass should not exceed ⅛″ and the sequence has to be followed carefully to accomplish this.



Front View

Job Sheet 30

☐ 29. Clean and inspect cap pass.

☐ 30. Have your instructor check your work.

☐ 31. Turn off machine.

☐ 32. Bend test as specified (refer to Job Sheet 25).

☐ 33. Check in tools and materials and clean area, or prepare for next job sheet, as directed by the instructor.

Evaluator's comments: ____

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Equipment, Applications, and Techniques
Unit 2

Job Sheet 31—Weld to Specifications a V-Groove Butt Joint in the Vertical Position with an E6010 Electrode Root and an E7018 Electrode Fill and Cap

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

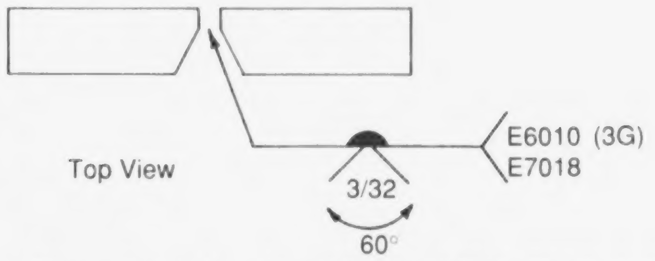
Evaluation criteria	**Rating**
Equipment setup and safety	______
Joint and root face preparation	______
Use of gap wire and tack welds	______
Root pass quality with E6010	______
Second and other pass quality with E7108	______
Final weld quality	______

A. Tools and materials

- SMAW machine with accessories
- Bend test machine
- Personal safety clothing
- Pliers
- Chipping hammer and wire brush
- Portable hand grinder
- Oxyacetylene cutting unit
- Soapstone
- Straightedge
- Cutting goggles
- Sparklighter
- File
- Mild steel plate as selected by instructor
- Gap wire, 3/32″
- Bevel square
- Welding helmet and safety glasses

B. Specifications

1. Joint design and weld symbol:



2. Filler metal and number of beads: E6010, E7018, 3/32″ or 1/8″

3. Electrical characteristics: DC+

Job Sheet 31

4. Position: 3G

5. Direction of welding: Vertical up

6. Cleaning: Chip, wire brush, and grind

7. Testing: Visual and bend test

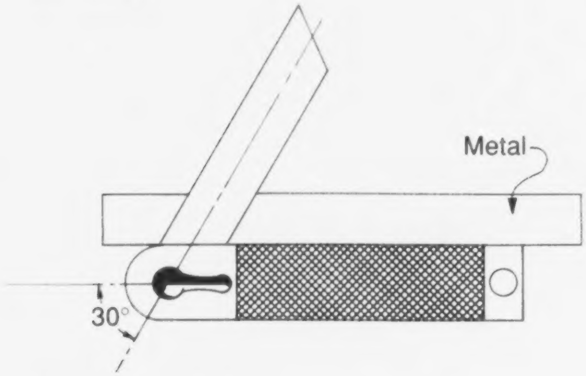
8. Technique: Whip and drag or weave

C. Procedure

☐ 1. Check work area to make sure it is free of flammable materials and well ventilated, and note the location of the nearest fire extinguisher.

☐ 2. Place plates to be beveled on cutting table.

☐ 3. Measure with the bevel square and mark the long side of the plate for a 30° bevel.



☐ 4. Light and adjust torch.

☐ 5. Place torch at a right angle to the plate and tilt 30° off the line to make the bevel cut on both plates.

Note: Beveling may be accomplished with a track torch as directed by your instructor, and you may be directed to bevel several plates at this time in order to save time in future job sheets.

☐ 6. Turn off torch and secure system.

Job Sheet 31

☐ 7. Secure plates in a vise one at a time, grind mill scale and slag from all surface areas to be welded, and be very careful to retain the 30° bevel angle.

☐ 8. Grind $\frac{1}{16}$" to $\frac{1}{8}$" root face along the entire length of the thinnest part of the bevel on all plates.

☐ 9. Attach ground clamp to worktable or workpiece.

☐ 10. Select correct polarity for electrode.

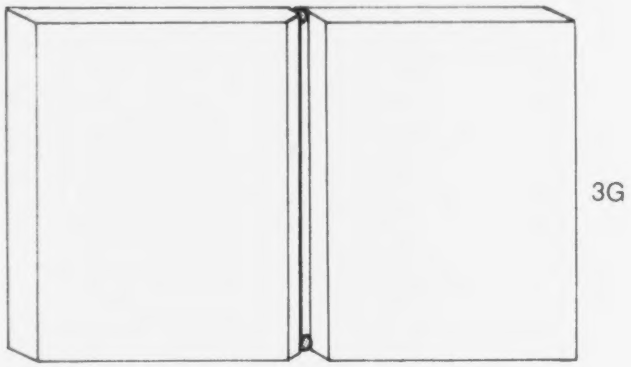
☐ 11. Turn on machine.

☐ 12. Put on safety gear and adjust to correct amperage by running a few test beads on scrap metal.

☐ 13. Align two plates face down on the worktable, using a $\frac{3}{32}$" gap wire to properly align and space them.

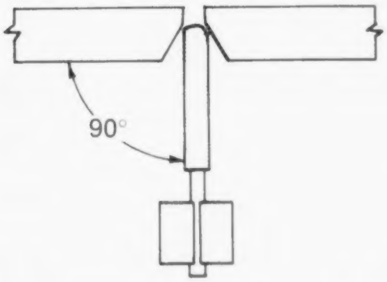
☐ 14. Tack weld both ends of the joint and remove gap wire.

☐ 15. Position the plates so that the joint is in the position indicated in specifications.

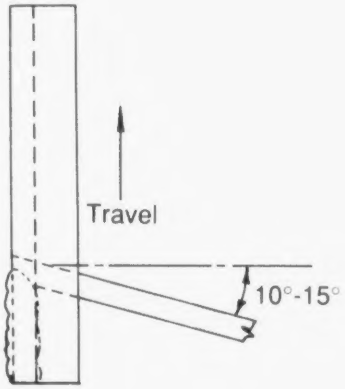


Job Sheet 31

☐ 16. Place electrode in holder and adjust to correct electrode angle over the joint.



Top View

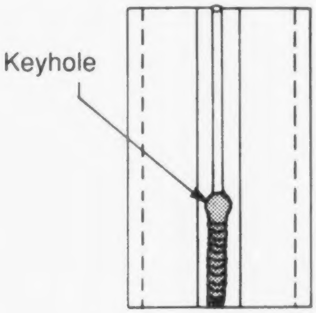


Side View

☐ 17. Start an arc and adjust electrode to correct arc length.

☐ 18. Make a puddle and immediately allow the keyhole to form.

Note: When the keyhole is properly formed, it allows the filler metal to completly penetrate the joint.



Front View

☐ 19. Whip the rod slightly forward to allow the keyhole to solidify, then whip the rod back to deposit more metal in the keyhole.

Note: Do not deposit filler metal outside the keyhole as you whip the rod away from the keyhole, and make sure your electrode is arcing in the bottom of the joint and not along the bevel.

Job Sheet 31

☐ 20. Make a tie-in at any point where the electrode is used up with the following procedure:

  a. Clean slag off the pass just completed with the chipping hammer and a wire brush.

  b. Grind the root pass with a portable grinder, and feather the end of the pass so that it becomes a little thinner near the keyhole pass.

  Note: Make other tie-ins with this same procedure.

☐ 21. Restart the arc deep in the groove at a point no more than ¼" from the keyhole, and hold a long arc to heat that portion of the pass.

☐ 22. Make another puddle and immediately continue with the keyhole and the slight whipping motion back and forth to keep it moving.

☐ 23. Repeat the procedure as required until the joint is completely welded.

☐ 24. Secure workpiece with pliers and clean and inspect root pass on both sides to make sure penetration is 100%.

☐ 25. Grind the entire length of the root pass.

☐ 26. Adjust amperage to proper setting for an E7018 electrode.

☐ 27. Use a weave technique to run a second pass over the entire length of the root pass, taking care not to blow a hole through the root pass.

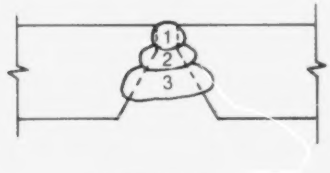
☐ 28. Secure workpiece with pliers and clean and inspect second pass to make sure it has good tie-in with the root pass.

☐ 29. Grind the entire length of the second pass.

Job Sheet 31

☐ 30. Use a weave or drag technique to lay beads for remainder of fill-up, and clean each pass before starting next pass.

Note: Numbers in the illustration indicate sequence, not quantity, and your instructor may direct you to use a weaving or drag technique on fill and cap beads.

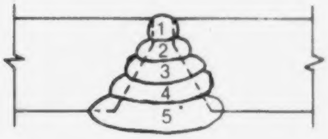


Top View

☐ 31. Clean fill-up stringer beads thoroughly to prepare for a cap pass.

☐ 32. Use a weaving or stringer technique to lay beads for the cap.

Note: The total height of the cap pass should not exceed 1/8" and the sequence has to be followed carefully to accomplish this.



Top View

☐ 23. Clean and inspect cap pass.

☐ 34. Have your instructor check your work.

☐ 35. Turn off machine.

☐ 36. Bend test as specified (refer to Job Sheet 25).

Job Sheet 31

☐ 37. Check in tools and materials and clean area,or prepare for next job sheet, as directed by the instructor.

Evaluator's comments: ________________________________

Equipment, Applications, and Techniques
Unit 2

Job Sheet 32—Weld to Specifications a V-Groove Butt Joint in the Overhead Position with an E6010 Electrode Root and an E7018 Electrode Fill and Cap

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

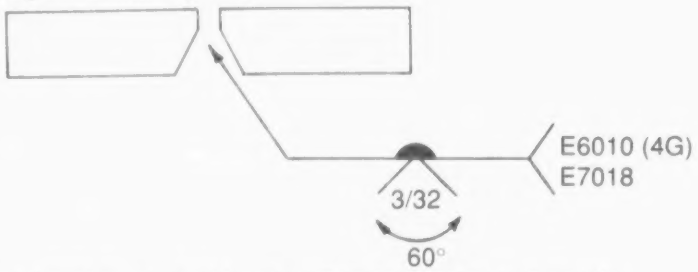
Evaluation criteria	**Rating**
Equipment setup and safety	______
Joint and root face preparation	______
Use of gap wire and tack welds	______
Root pass quality with E6010	______
Second and other pass quality with E7108	______
Final weld quality	______

A. Tools and materials

- SMAW machine with accessories
- Bend test machine
- Personal safety clothing and equipment
- Pliers
- Chipping hammer and wire brush
- Portable hand grinder
- Oxyacetylene cutting unit
- Soapstone
- Straightedge
- Cutting goggles
- Sparklighter
- File
- Mild steel plate as selected by instructor
- Gap wire, 3/32″
- Bevel square
- Welding helmet and safety glasses

B. Specifications

1. Joint design and weld symbol:



2. Filler metal and number of beads: E6010, E7018, 3/32″ or 1/8″

3. Electrical characteristics: DC+

Job Sheet 32

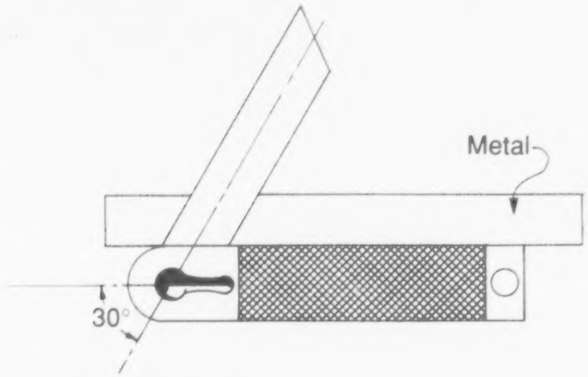
4. Position: 4G
5. Direction of welding: N/A
6. Cleaning: Chip, wire brush, and grind
7. Testing: Visual and bend test
8. Technique: Whip and drag

C. Procedure

☐ 1. Check work area to make sure it is free of flammable materials and well ventilated, and note the location of the nearest fire extinguisher.

☐ 2. Place plates to be beveled on cutting table.

☐ 3. Measure with the bevel square and mark the long side of the plate for a 30° bevel.



☐ 4. Light and adjust torch.

☐ 5. Place torch at a right angle to the plate and tilt 30° off the line to make the bevel cut on both plates.

Note: Beveling may be accomplished with a track torch as directed by your instructor, and you may be directed to bevel several plates at this time in order to save time in future job sheets.

☐ 6. Turn off torch and secure system.

Job Sheet 32

☐ 7. Secure plates in a vise one at a time, grind mill scale and slag from all surface areas to be welded, and be very careful to retain the 30° bevel angle.

☐ 8. Grind 1/16″ to 1/8″ root face along the entire length of the thinnest part of the bevel on all plates.

☐ 9. Attach ground clamp to worktable or workpiece.

☐ 10. Select correct polarity for electrode.

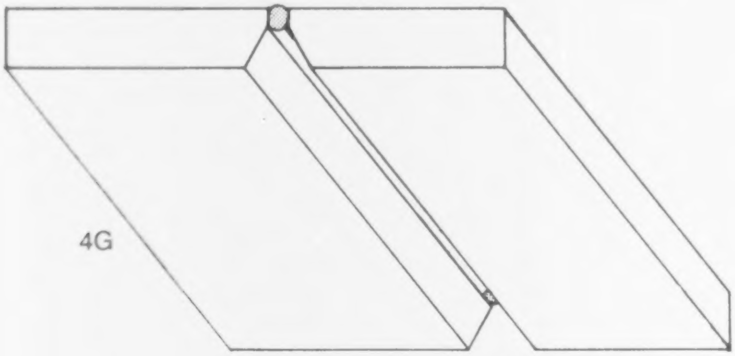
☐ 11. Turn on machine.

☐ 12. Put on safety gear and adjust to correct amperage by running a few test beads on scrap metal.

☐ 13. Align two plates face down on the worktable, using a 3/32″ gap wire to properly align and space them.

☐ 14. Tack weld both ends of the joint and remove gap wire.

☐ 15. Position the plates so that the joint is in the position indicated in specifications.



☐ 16. Make a tie-in at any point where the electrode is used up with the following procedure:

a. Clean slag off the pass just completed with the chipping hammer and a wire brush.

Job Sheet 32

b. Grind the root pass with a portable grinder, and feather the end of the pass so that it becomes a little thinner near the keyhole pass.

Note: Make other tie-ins with this same procedure.

☐ 17. Restart the arc deep in the groove at a point no more than ¼" from the keyhole, and hold a long arc to heat that portion of the pass.

☐ 18. Make another puddle and immediately continue with the keyhole and the slight whipping motion back and forth to keep it moving.

☐ 19. Repeat the procedure as required until the joint is completely welded.

☐ 20. Secure workpiece with pliers and clean and inspect root pass on both sides to make sure penetration is 100%.

☐ 21. Grind the entire length of the root pass.

☐ 22. Adjust amperage to proper setting for an E7018 electrode.

☐ 23. Use a drag technique to run a second pass over the entire length of the root pass, taking care not to blow a hole through the root pass.

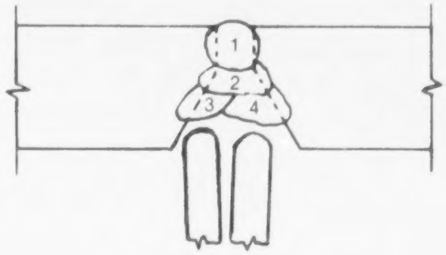
☐ 24. Secure workpiece with pliers and clean and inspect second pass to make sure it has good tie-in with the root pass.

☐ 25. Grind the entire length of the second pass.

Job Sheet 32

☐ 26. Use a drag technique to lay stringer beads for remainder of fill-up and clean each stringer before starting next pass.

Note: Numbers in the illustration indicate sequence, not quantity.

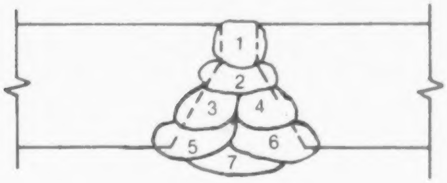


Front View

☐ 27. Clean fill-up stringer beads thoroughly to prepare for a cap pass.

☐ 28. Use a drag technique to lay stringer beads for the cap so that they pyramid from the toes to the face with the final cap stringer in approximately the center of the joint.

Note: The total height of the cap pass should not exceed ⅛" and the sequence has to be followed carefully to accomplish this.



Front View

☐ 29. Clean and inspect cap pass.

☐ 30. Have your instructor check your work.

☐ 31. Turn off machine.

☐ 32. Bend test as specified (refer to Job Sheet 25).

Job Sheet 32

☐ 33. Check in tools and materials and clean area, or prepare for next job sheet, as directed by the instructor.

Evaluator's comments: ______________________________

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Equipment, Applications, and Techniques
Unit 2

Job Sheet 33—Weld to Specifications an Open-Root Corner Joint in the Flat Position with an E6010 Electrode

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

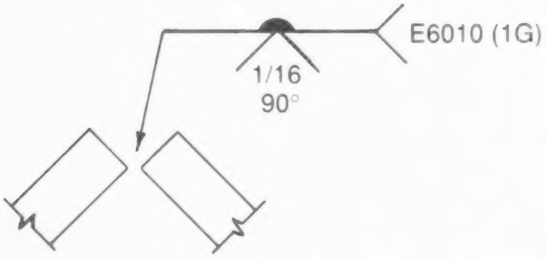
Evaluation criteria	Rating
Equipment setup and safety	______
Use of gap wire and tack welds	______
Proper root pass tie-ins	______
100% penetration on root pass	______
Second pass and cleaning	______
Fill-up passes and cleaning	______
Cap pass and cleaning	______
Final weld quality	______

A. Tools and materials

SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Portable hand grinder
Mild steel plate, 3/8"
Gap wire, 1/16"
Welding helmet and safety glasses

B. Specifications

1. Joint design and weld symbol:



2. Filler metal and number of beads: E6010, 3/32" or 1/8"

Job Sheet 33

3. Electrical characteristics: DC+
4. Position: 1G
5. Direction of welding: N/A
6. Cleaning: Chip, wire brush, and grind
7. Testing: Visual
8. Technique: Whipping

C. Procedure

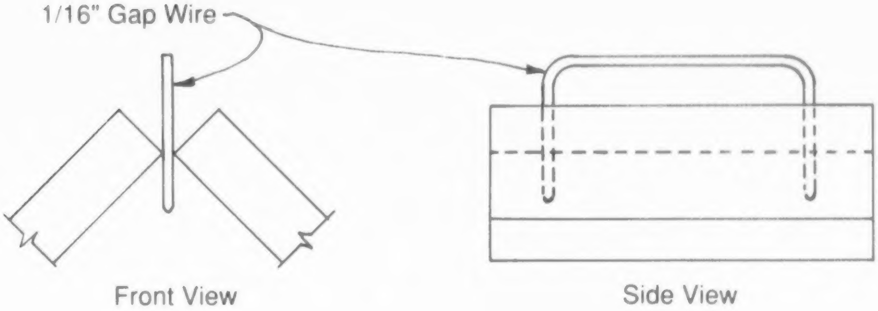
☐ 1. Attach ground clamp to workpiece.

☐ 2. Select proper polarity for an E6010 electrode.

☐ 3. Turn on machine.

☐ 4. Put on safety gear and adjust to correct amperage by running a few test beads on scrap metal.

☐ 5. Position plates to form a 90° corner and use $\frac{1}{16}$" gap wire to align the root gap.

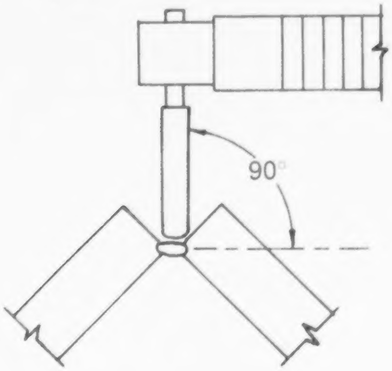


☐ 6. Tack both ends of the joint and remove gap wire.

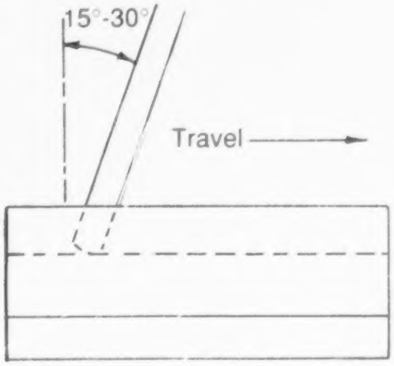
☐ 7. Place the plates so that the joint is in the position indicated in the specifications.

Job Sheet 33

☐ 8. Place electrode in holder and adjust to correct electrode angle over the joint.



Front View

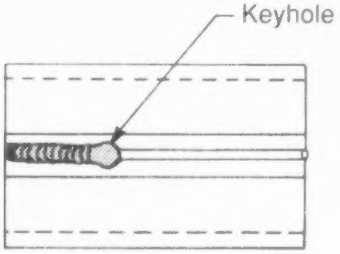


Side View

☐ 9. Start an arc and adjust electrode to correct arc length.

☐ 10. Make a puddle and immediately allow the keyhole to form.

Note: When the keyhole is properly formed, it allows the filler metal to completly penetrate the joint.



Top View

☐ 11. Whip the rod slightly forward to allow the keyhole to solidify, then whip the rod back to deposit more metal in the keyhole.

Note: Do not deposit filler metal outside the keyhole as you whip the rod away from the keyhole, and make sure your electrode is arcing in the bottom of the joint and not along the bevel.

Job Sheet 33

☐ 12. Make a tie-in at any point where the electrode is used up with the following procedure:

  a. Clean slag off the pass just completed with the chipping hammer and a wire brush.

  b. Grind the root pass with a portable grinder, and feather the end of the pass so that it becomes a little thinner near the keyhole pass.

☐ 13. Restart the arc deep in the groove at a point no more than ¼" from the keyhole, and hold a long arc to heat that portion of the pass.

☐ 14. Make another puddle and immediately continue with the keyhole and the slight whipping motion back and forth to keep it moving.

☐ 15. Repeat the procedure as required until the joint is completely welded.

☐ 16. Secure workpiece with pliers and clean and inspect root pass on both sides to make sure penetration is 100%.

☐ 17. Grind the entire length of the root pass.

☐ 18. Increase amperage on welding machine about 5 to 10 amps (if required).

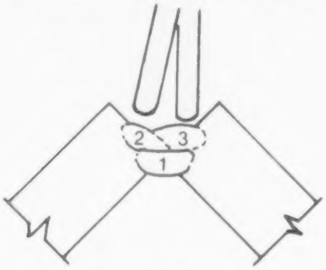
☐ 19. Use a whipping technique to run a second pass over the entire length of the root pass, taking care not to blow a hole through the root pass.

☐ 20. Secure workpiece with pliers and clean and inspect second pass to make sure it has good tie-in with the root pass.

☐ 21. Grind the entire length of the hot pass, if required.

☐ 22. Use a whipping technique to lay stringer beads for remainder of fill-up and clean each stringer before starting next pass.

Note: Numbers in the illustration indicate sequence, not quantity.



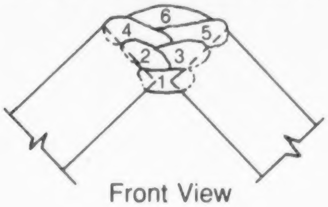
Front View

Job Sheet 33

☐ 23. Clean filler beads thoroughly to prepare for a cap pass.

☐ 24. Use a whipping technique to lay stringer beads for the cap so that they pyramid from the toes to the face with the final cap stringer in approximately the center of the joint.

Note: The total height of the cap pass should not exceed ⅛″ and the sequence has to be followed carefully to accomplish this.



Front View

☐ 25. Clean and inspect cap pass.

☐ 26. Have your instructor check your work.

☐ 27. Turn off machine.

☐ 28. Check in tools and materials and clean area, or prepare for next job sheet, as directed by the instructor.

Evaluator's comments: ______________________________

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Equipment, Applications, and Techniques
Unit 2

Job Sheet 34—Weld to Specifications an Open-Root Corner Joint in the Horizontal Position with an E6010 Electrode

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

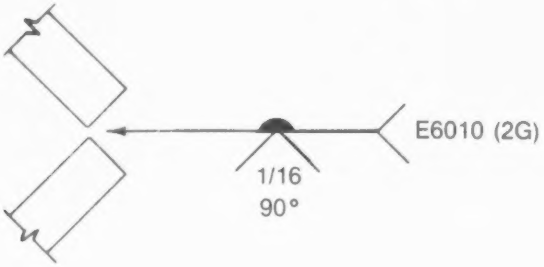
Evaluation criteria	**Rating**
Equipment setup and safety	
Use of gap wire and tack welds	
Proper root pass tie-ins	
100% penetration on root pass	
Second pass and cleaning	
Fill-up passes and cleaning	
Cap pass and cleaning	
Final weld quality	

A. Tools and materials

SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Portable hand grinder
Mild steel plate as selected by instructor
Gap wire, 1/16"
Welding helmet and safety glasses

B. Specifications

1. Joint design and weld symbol:



Side View

Job Sheet 34

2. Filler metal and number of beads: E6010, 3/32" or 1/8"
3. Electrical characteristics: DC+
4. Position: 2G
5. Direction of welding: N/A
6. Cleaning: Chip, wire brush, and grind
7. Testing: Visual
8. Technique: Whipping

C. Procedure

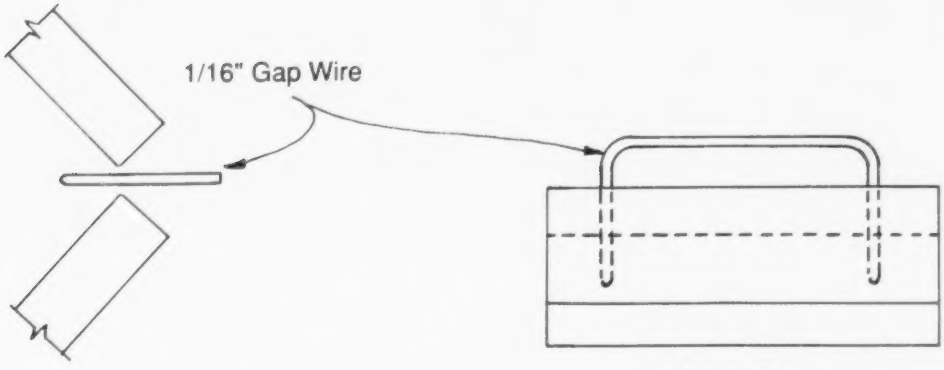
☐ 1. Attach ground clamp to workpiece.

☐ 2. Select proper polarity for an E6010 electrode.

☐ 3. Turn on machine.

☐ 4. Put on safety gear and adjust to correct amperage by running a few test beads on scrap metal.

☐ 5. Position plates to form a 90° corner and use 1/16" gap wire to align the root gap.

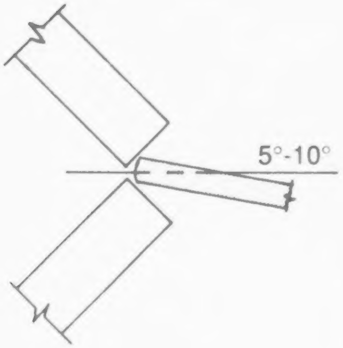


☐ 6. Tack both ends of the joint and remove gap wire.

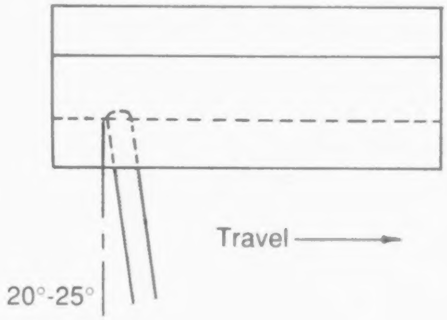
☐ 7. Place the plates so that the joint is in the position indicated in the specifications.

Job Sheet 34

☐ 8. Place electrode in holder and adjust to correct electrode angle over the joint.



Front View

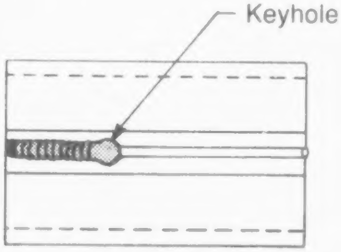


Top View

☐ 9. Start an arc and adjust electrode to correct arc length.

☐ 10. Make a puddle and immediately allow the keyhole to form.

Note: When the keyhole is properly formed, it allows the filler metal to completly penetrate the joint.



Front View

☐ 11. Whip the rod slightly forward to allow the keyhole to solidify, then whip the rod back to deposit more metal in the keyhole.

Note: Do not deposit filler metal outside the keyhole as you whip the rod away from the keyhole, and make sure your electrode is arcing in the bottom of the joint and not along the bevel.

Job Sheet 34

☐ 12. Make a tie-in at any point where the electrode is used up with the following procedure:

a. Clean slag off the pass just completed with the chipping hammer and a wire brush.

b. Grind the root pass with a portable grinder, and feather the end of the pass so that it becomes a little thinner near the keyhole pass.

☐ 13. Restart the arc deep in the groove at a point no more than ¼″ from the keyhole, and hold a long arc to heat that portion of the pass.

☐ 14. Make another puddle and immediately continue with the keyhole and the slight whipping motion back and forth to keep it moving.

☐ 15. Repeat the procedure as required until the joint is completely welded.

☐ 16. Secure workpiece with pliers and clean and inspect root pass on both sides to make sure penetration is 100%.

☐ 17. Grind the entire length of the root pass.

☐ 18. Increase amperage on welding machine about 5 to 10 amps (if required).

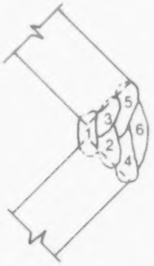
☐ 19. Use a whipping technique to run a second pass over the entire length of the root pass, taking care not to blow a hole through the root pass.

☐ 20. Secure workpiece with pliers and clean and inspect second pass to make sure it has good tie-in with the root pass.

☐ 21. Grind the entire length of the second pass, if required.

☐ 22. Use a whipping technique to lay stringer beads for remainder of fill-up and clean each stringer before starting next pass.

Note: Numbers in the illustration indicate sequence, not quantity.



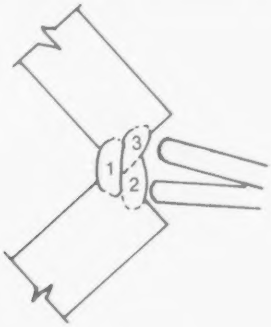
Front View

Job Sheet 34

☐ 23. Clean filler beads thoroughly to prepare for a cap pass.

☐ 24. Use a whipping technique to lay stringer beads for the cap so that they pyramid from the toes to the face with the final cap stringer in approximately the center of the joint.

Note: The total height of the cap pass should not exceed ⅛" and the sequence has to be followed carefully to accomplish this.



Front View

☐ 25. Clean and inspect cap pass.

☐ 26. Have your instructor check your work.

☐ 27. Turn off machine.

☐ 28. Check in tools and materials and clean area, or prepare for next job sheet, as directed by the instructor.

Evaluator's comments: ______________________________

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Equipment, Applications, and Techniques
Unit 2

Job Sheet 35—Weld to Specifications an Open-Root Corner Joint in the Vertical Position with an E6010 Electrode

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

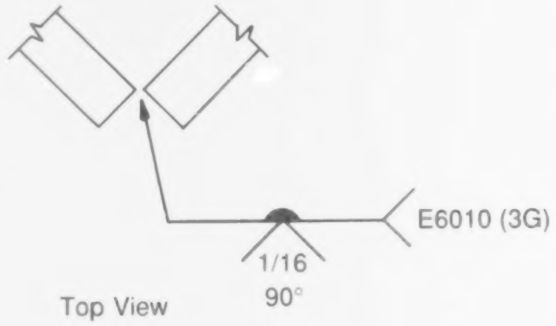
Evaluation criteria	Rating
Equipment setup and safety	______
Use of gap wire and tack welds	______
Proper root pass tie-ins	______
100% penetration on root pass	______
Second pass and cleaning	______
Fill-up passes and cleaning	______
Cap pass and cleaning	______
Final weld quality	______

A. Tools and materials

SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Portable hand grinder
Mild steel plate as selected by instructor
Gap wire, 1/16″
Welding helmet and safety glasses

B. Specifications

1. Joint design and weld symbol:



Job Sheet 35

2. Filler metal and number of beads: E6010, 3/32" or 1/8"
3. Electrical characteristics: DC+
4. Position: 3G
5. Direction of welding: Vertical up
6. Cleaning: Chip, wire brush, and grind
7. Testing: Visual
8. Technique: Whipping

C. Procedure

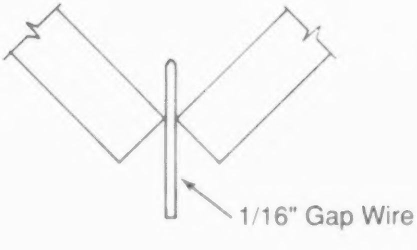
☐ 1. Attach ground clamp to workpiece.

☐ 2. Select proper polarity for an E6010 electrode.

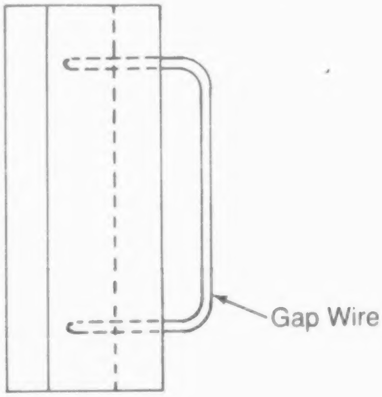
☐ 3. Turn on machine.

☐ 4. Put on safety gear and adjust to correct amperage by running a few test beads on scrap metal.

☐ 5. Position plates to form a 90° corner and use 1/16" gap wire to align the root gap.



Top View



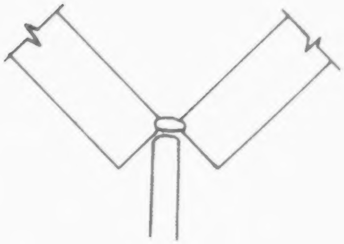
Side View

☐ 6. Tack both ends of the joint and remove gap wire.

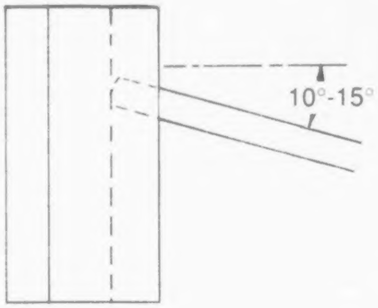
☐ 7. Place the plates so that the joint is in the position indicated in the specifications.

Job Sheet 35

☐ 8. Place electrode in holder and adjust to correct electrode angle over the joint.



Top View

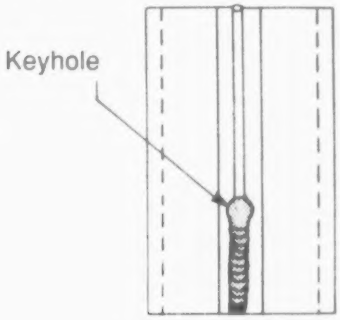


Side View

☐ 9. Start an arc and adjust electrode to correct arc length.

☐ 10. Make a puddle and immediately allow the keyhole to form.

Note: When the keyhole is properly formed, it allows the filler metal to completly penetrate the joint.



Front View

☐ 11. Whip the rod slightly forward to allow the keyhole to solidify, then whip the rod back to deposit more metal in the keyhole.

Note: Do not deposit filler metal outside the keyhole as you whip the rod away from the keyhole, and make sure your electrode is arcing in the bottom of the joint and not along the bevel.

Job Sheet 35

☐ 12. Make a tie-in at any point where the electrode is used up with the following procedure:

  a. Clean slag off the pass just completed with the chipping hammer and a wire brush.

  b. Grind the root pass with a portable grinder, and feather the end of the pass so that it becomes a little thinner near the keyhole pass.

☐ 13. Restart the arc deep in the groove at a point no more than ¼″ from the keyhole, and hold a long arc to heat that portion of the pass.

☐ 14. Make another puddle and immediately continue with the keyhole and the slight whipping motion back and forth to keep it moving.

☐ 15. Repeat the procedure as required until the joint is completely welded.

☐ 16. Secure workpiece with pliers and clean and inspect root pass on both sides to make sure penetration is 100%.

☐ 17. Grind the entire length of the root pass.

☐ 18. Increase amperage on welding machine about 5 to 10 amps (if required).

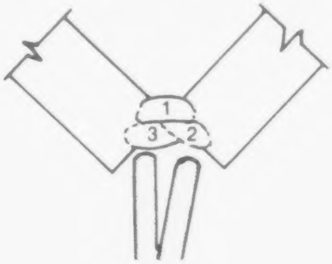
☐ 19. Use a whipping technique to run a second pass over the entire length of the root pass, taking care not to blow a hole through the root pass.

☐ 20. Secure workpiece with pliers and clean and inspect second pass to make sure it has good tie-in with the root pass.

☐ 21. Grind the entire length of the second pass, if required.

☐ 22. Use a whipping technique to lay stringer beads for remainder of fill-up and clean each stringer before starting next pass.

Note: Numbers in the illustration indicate sequence, not quantity.



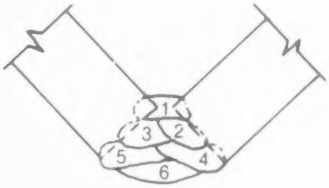
Top View

Job Sheet 35

☐ 23. Clean filler beads thoroughly to prepare for a cap pass.

☐ 24. Use a whipping technique to lay stringer beads for the cap so that they pyramid from the toes to the face with the final cap stringer in approximately the center of the joint.

Note: The total height of the cap pass should not exceed ⅛" and the sequence has to be followed carefully to accomplish this.



Top View

☐ 25. Clean and inspect cap pass.

☐ 26. Have your instructor check your work.

☐ 27. Turn off machine.

☐ 28. Check in tools and materials and clean area, or prepare for next job sheet, as directed by the instructor.

Evaluator's comments: ______________________________

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Equipment, Applications, and Techniques
Unit 2

Job Sheet 36—Weld to Specifications an Open-Root Corner Joint in the Overhead Position with an E6010 Electrode

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

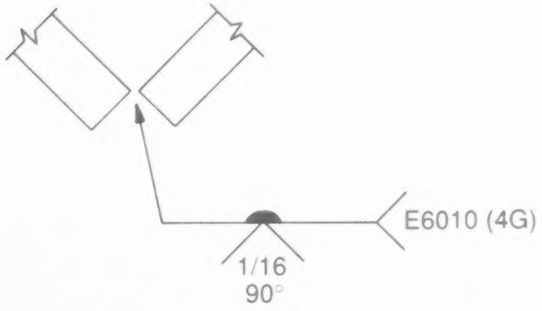
Evaluation criteria	**Rating**
Equipment setup and safety	______
Use of gap wire and tack welds	______
Proper root pass tie-ins	______
100% penetration on root pass	______
Second pass and cleaning	______
Fill-up passes and cleaning	______
Cap pass and cleaning	______
Final weld quality	______

A. Tools and materials

SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Portable hand grinder
Mild steel plate as selected by instructor
Gap wire, 1/16″
Welding helmet and safety glasses

B. Specifications

1. Joint design and weld symbol:



Job Sheet 36

2. Filler metal and number of beads: E6010, 3/32″ or 1/8″
3. Electrical characteristics: DC+
4. Position: 4G
5. Direction of welding: N/A
6. Cleaning: Chip, wire brush, and grind
7. Testing: Visual
8. Technique: Whipping

C. Procedure

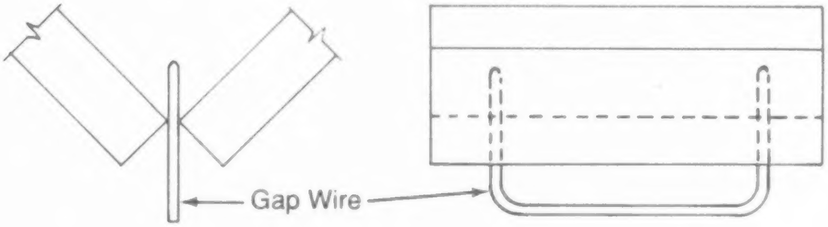
☐ 1. Attach ground clamp to workpiece.

☐ 2. Select proper polarity for an E6010 electrode.

☐ 3. Turn on machine.

☐ 4. Put on safety gear and adjust to correct amperage by running a few test beads on scrap metal.

☐ 5. Position plates to form a 90° corner and use 1/16″ gap wire to align the root gap.



Front View

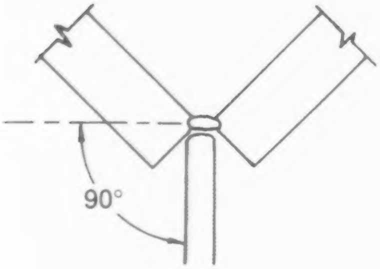
Side View

☐ 6. Tack both ends of the joint and remove gap wire.

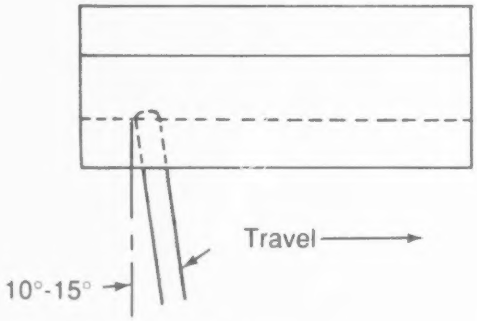
☐ 7. Place the plates so that the joint is in the position indicated in the specifications.

Job Sheet 36

☐ 8. Place electrode in holder and adjust to correct electrode angle over the joint.



Front View

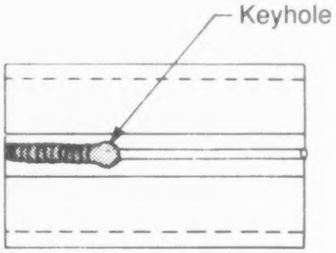


Side View

☐ 9. Start an arc and adjust electrode to correct arc length.

☐ 10. Make a puddle and immediately allow the keyhole to form.

Note: When the keyhole is properly formed, it allows the filler metal to completly penetrate the joint.



Bottom View

☐ 11. Whip the rod slightly forward to allow the keyhole to solidify, then whip the rod back to deposit more metal in the keyhole.

Note: Do not deposit filler metal outside the keyhole as you whip the rod away from the keyhole, and make sure your electrode is arcing in the bottom of the joint and not along the bevel.

Job Sheet 36

☐ 12. Make a tie-in at any point where the electrode is used up with the following procedure:

  a. Clean slag off the pass just completed with the chipping hammer and a wire brush.

  b. Grind the root pass with a portable grinder, and feather the end of the pass so that it becomes a little thinner near the keyhole pass.

☐ 13. Restart the arc deep in the groove at a point no more than ¼″ from the keyhole, and hold a long arc to heat that portion of the pass.

☐ 14. Make another puddle and immediately continue with the keyhole and the slight whipping motion back and forth to keep it moving.

☐ 15. Repeat the procedure as required until the joint is completely welded.

☐ 16. Secure workpiece with pliers and clean and inspect root pass on both sides to make sure penetration is 100%.

☐ 17. Grind the entire length of the root pass.

☐ 18. Increase amperage on welding machine about 5 to 10 amps (if required).

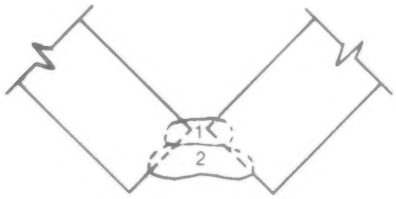
☐ 19. Use a whipping technique to run a second pass over the entire length of the root pass, taking care not to blow a hole through the root pass.

☐ 20. Secure workpiece with pliers and clean and inspect second pass to make sure it has good tie-in with the root pass.

☐ 21. Grind the entire length of the second pass, if required.

☐ 22. Use a whipping technique to lay stringer beads for remainder of fill-up and clean each stringer before starting next pass.

Note: Numbers in the illustration indicate sequence, not quantity.



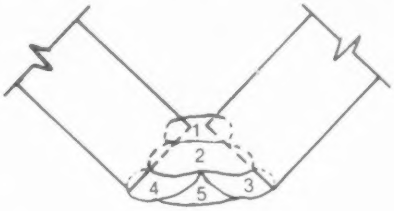
Front View

Job Sheet 36

☐ 23. Clean filler beads thoroughly to prepare for a cap pass.

☐ 24. Use a whipping technique to lay stringer beads for the cap so that they pyramid from the toes to the face with the final cap stringer in approximately the center of the joint.

Note: The total height of the cap pass should not exceed ⅛" and the sequence has to be followed carefully to accomplish this.



Top View

☐ 25. Clean and inspect cap pass.

☐ 26. Have your instructor check your work.

☐ 27. Turn off machine.

☐ 28. Check in tools and materials and clean area, or prepare for next job sheet, as directed by the instructor.

Evaluator's comments: ______________________________

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Equipment, Applications, and Techniques
Unit 2

Job Sheet 37—Gouge a Piece of Mild Steel with the Air Carbon Arc Cutting Process

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Equipment setup and safety	____
Proper air and power connections	____
Air adjustment and check for moisture	____
Proper electrode and air jet angles	____
Quality of finished cut	____
Equipment shut down	____

A. Tools and materials

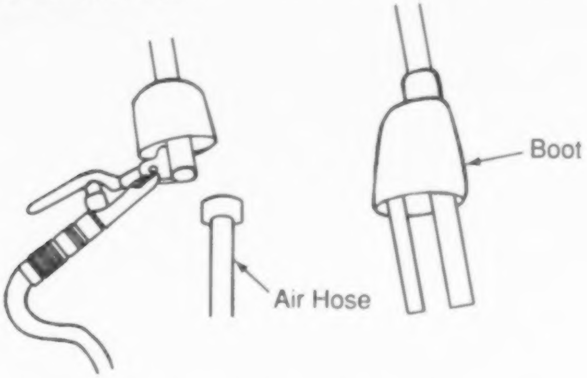
Personal arc welding safety clothing and equipment
Arc welder
Air carbon arc electrode holder
Air carbon arc cutting electrode
Compressed air supply with regulator
Air hose
Chipping hammer
Mild steel plate as selected by instructor
Welding helmet and safety glasses

B. Procedures

☐ 1. Check area to make sure it is free of flammable materials and is well ventilated, and note the location of the nearest fire extinguisher.

Job Sheet 37

☐ 2. Expose air and power connections by pushing back insulated boot on CAC-A electrode holder.



☐ 3. Attach the welding machine electrode holder to the copper tab on the power cable assembly.

☐ 4. Attach the air hose to the air hose connection and replace the insulated boot over the air connection and the jaws of the welding machine electrode holder.

☐ 5. Attach regulator to compressed air supply and attach air hose to regulator.

☐ 6. Adjust regulator to between 60 and 100 psi and spray air on a piece of metal to make sure it is moisture-free.

Note: If moisture collects on the metal, compressed air should be checked because air tanks may need to be drained of moisture.

☐ 7. Select a standard carbon electrode that will function best with DC+ polarity.

Job Sheet 37

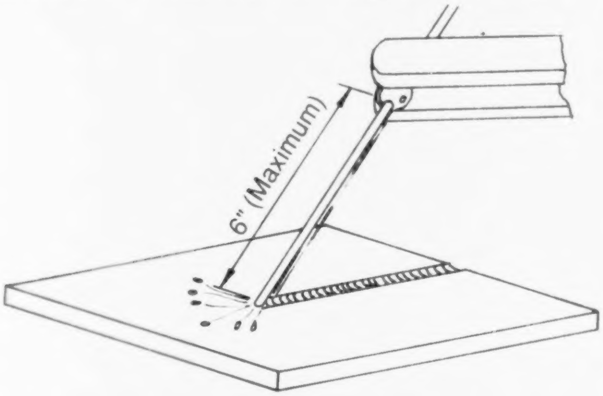
☐ 8. Adjust amperage according to electrode diameter.

ELECTRODE SIZE		COPPER COATED DC TYPES (Reverse Polarity)		AC TYPES	GROOVE WIDTH (Approximate)	
in.	mm	Amps		Amps	in.	mm
5/32	4	90-200		—	3/16	5
3/16	5	150-250		200-250	1/4	6
1/4	6	250-400		300-400	5/16	8
5/16	8	300-500		325-425	7/16	11
3/8	10	350-600		400-550	1/2	13
1/2	13	600-1000		500-600	5/8	16
5/8	16	800-1250		—	3/4	19
3/4	19	1200-1500		—	7/8	22
Semi-Round		Flat Position	Round Position			
3/8	10	200-375	250-500	—	1/2	13
5/8	16	350-1000	600-1200	—	3/4	19
Flats						
3/8	10	400 (max.)		—	1/2	13
5/8	16	500 (max.)		—	3/4	19

☐ 9. Attach ground clamp to workpiece.

☐ 10. Turn on welding machine.

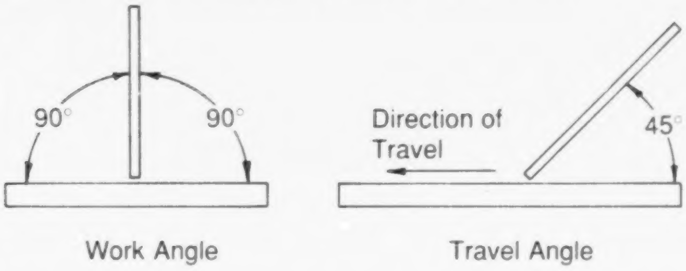
☐ 11. Place the electrode in the jaws of the CAC-A electrode holder with no more than 6″ of electrode extending in front of the air jets.



☐ 12. Position air jets under the CAC-A electrode so that air is directed at the point of arcing to blow away the molten metal.

Job Sheet 37

☐ 13. Position the CAC-A electrode angle as indicated.



☐ 14. Turn on air with the air valve on the CAC-A electrode holder.

☐ 15. Start arc and swing the CAC-A electrode in and out of the metal, taking care to maintain the arc and not let it break.

☐ 16. Move the electrode in the direction of the cut just as the arc first comes out on the back side of the base metal.

☐ 17. Move the CAC-A electrode in a slight in and out motion the entire length of the cut.

☐ 18. Finish cut, stop, and turn off jet air by using the air valve on the electrode holder.

☐ 19. Place CAC-A electrode holder in a safe position where it cannot spark.

☐ 20. Have your instructor check your cut.

☐ 21. Make adjustments, if required, and complete other cuts as directed by instructor.

☐ 22. Turn off air supply and welding machine.

☐ 23. Remove the CAC-A electrode holder from the air hose, and remove the welding machine electrode holder from the insulated boot.

☐ 24. Check in tools and materials and clean the area.

Evaluator's comments: ____

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